RATIONAL RECREATIONS,

In which the PRINCIPLES of

NUMBERS

AND

NATURAL PHILOSOPHY

Are clearly and copiously elucidated,

BY A SERIES OF

EASY, ENTERTAINING, INTERESTING EXPERIMENTS.

Among which are

All those commonly performed with the CARDS.

By W. HOOPER, M. D.

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MDCCLXXXVII.

RATIONAL
RECREATIONS.

VOLUME THE SECOND.

CONTAINING

EXPERIMENTS

IN

OPTICS, CHROMATICS,

AND

ACOUSTICS.

DESCRIPTION of the PLATES.

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FIG. I. Shows the manner in which the rays of light converge and diverge.

Fig. 2. Different objects seen under the same optic angle.

Fig. 3. The refraction of a ray of light, AB, in passing through different mediums.

Fig. 4. The different sorts of lenses.

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Fig. 3. Shows the structure of a reflecting telescope. G H is a large concave metalline mirror,

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Fig. 3. The portable camera obscura. E is a plate of glass, placed in the frame A B C D, to which the image of the objects that enter the tube O, are reflected by the mirror N. The four legs and the pieces that compose the case H, have hinges, by which they fold up.

Fig. 4. The magic lantern. ABCD is a tin box, in one end of which is a concave mirror G; at the opposite end is a convex lens L, and before it a tin tube O, that has an opening MN, through which are passed the glasses that have the objects painted

painted on them. In the tube O is placed another that is moveable, and that contains two lenſes P and Q, by which the objects on the glaſſes are thrown on the wall: K is a lamp, and E, F the funnel by which the ſmoke comes out, and its cover that keeps in the light.

PLATE IV. p. 50.

Fig. 1, and 2. Are two plates of glaſs, to paſs through the groove in the magic lantern at the ſame time, and by which the appearance of a tempeſt is to be exhibited.

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Fig. 4. G I a concave mirror, A C an object at a greater diftance than in the laft figure ; DF the image before the mirror, inverted and diminifhed.

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Fig. 4. The box for the four magical mirrors. ABCD the body of the box, againft whofe four infides the mirrors are placed. BNLI a frame of glafs confifting of four inclined plates, and one at top that is horizontal ; by the latter the images placed on the bottom of the box are feen reflected by the mirrors.

Fig. 5. A plan for difpofing the objects in the box, Fig. 4.

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Fig. 1. The enchanted palace. Againft the fix pillars mirrors are fixed, that meet in the center, and between each triangular divifion objects are placed, that are reflected by the mirrors. ABCDEF is the plan of the bafe of the palace.

Fig.

Fig. 2. Is a ſquare on which a regular figure is drawn, that when transferred to the correſponding diviſions of Fig. 3, appears deformed, but when ſeen in a mirror placed at FG, from a point over B, appears exactly the ſame as on Fig. 2.

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Fig. 5. Is a column placed on the middle of the box, and in which the fpectators feem to fee the objects fhown by the perfpectives.

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Fig.

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Fig. 5. The prismatic camera obscura. F *f* two rays of light that being refracted by the prisms A, B, C, and *a*, *b*, *c*, form the spectrum M N, which appears to be painted with all the original colours.

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Fig. 2, and 3. The machine for exhibiting co-

lorific

lorific mufic. The fhaded parts in fig. 2, reprefent the colours. F is the fcrew on which it turns, G a wheel that is moved by the endlefs fcrew H.

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PLATE XV. p. 174.

Fig. 1, 2, and 3, The plans for drawing an irregular figure that will appear regular when feen through a hole in the ftand Fig. 4, placed in the proper pofition.

PLATE XVI. p. 180.

Fig. 1, 2, and 3. The plans for drawing an irregular figure, which when feen from two oppofite points of view, prefents two regular figures.

Fig. 4. A pafteboard in which lines are cut, and over them the paper Fig. 5, that contains the drawing that is to be pafted.

PLATE XVII. p. 190.

Fig. 1, and 2. The apparatus for drawing an irregular figure on the bafe of a cone, that appears regular from the point H; FEG the cone; MN the pofition of a glafs on which the regular figure is drawn, and that is projected on the cone

by

by the lamp Fig. 2, when placed in the room of the ſtand H I.

Fig. 3. The machine for drawing any object correctly. E A C the tube for viewing the object; BFDG the frame, ſhown more clearly in Fig. 4, by which the parts of the object are transferred to ſimilar diviſions on a paper.

Fig. 5. The box for illuminated proſpects. EFGH the back of the box in which the prints are placed, and behind them lamps or candles.

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Fig. 3. The apparatus for the ventroſal ſymphony. A B the vane that gives motion to the machine; C, D, G, H, I, M, wheels and pinions that ſerve to move the barrel N O, in which are a number of ſtops, that ſtrike a ſet of bells.

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PLATE XIX. p. 240.

Fig. 1. Shows the mechaniſm of the great organ. O, O, are the handles that puſh down the bellows,

T T:

TT: *l*, *l*, are the handles that turn the rollers R, R, that by means of the arms *c*, *f*, pull out the ſliders *b*, *g*, and give liberty to the pipes placed over any row of the holes to ſound; C, D, E, &c. are the keys, which being put down open the valves V, that admit the air to the pipes: KKK is the wind-cheſt, that receives the air by the port-vent 4. X is a flute-pipe of wood; Y a trumpet-pipe of metal; Z a flute pipe of metal.

Fig. 2. Shows the conſtruction of a valve, with the wire that opens it and the ſpring that ſhuts it.

Fig. 3. The inſide of a flute pipe. A B the foot, B D the body; E F the partition; B C the mouth.

Fig. 4. A reed pipe; A B the foot: C D the ſhallot or reed; K L a plate of copper fitted into the mold at I, but being looſe at its extremity K, the air makes it ſhake againſt the reed:

RATIONAL.

RATIONAL RECREATIONS.

OPTICS.

THE ſcience of optics explains the nature of viſion, by inveſtigating the cauſes of the various phenomena that ariſe from the refraction and reflection of light. It is divided into Dioptrics, Catoptrics, and Chromatics*. The firſt treats of refraction; the ſecond, of reflection; and the laſt, of colours.

GENERAL DEFINITIONS.

1. When the rays of light that iſſue from any body, continually recede from

* Theſe terms are derived from the Greek; the firſt from the word *dioptra*, a perſpective glaſs; the ſecond from *katoptron*, a mirror; and the laſt from *chromata*, colours.

 each

each other, as the rays AB and AC (Plate I. Fig. 1.) they are ſaid to diverge.

2. When rays in their progreſs draw continually nearer to each other, as the rays BF and CF, (Plate I. Fig. 1.) they are ſaid to converge.

3. That point in which converging rays all meet, is called their focus; as the point F, in the ſame figure.

4. An optic angle is the ſpace contained between two lines drawn from the extremities of any object to the eye. Thus AEB or CED (Plate I. Fig. 2.) are the optic angles under which the objects AB and CD appear to the eye at E.

GENERAL APHORISMS.

1. The motion of light is not inſtantaneous but progreſſive*.

2. All rays of light naturally proceed in right lines.

3. No object can be ſeen diſtinctly at a leſs diſtance than about eight inches.

4. To produce diſtinct viſion, the rays of light muſt be parallel when they enter the eye, and the object well illumined.

5. Rays of light that come from a far diſtant object, are to be conſidered as parallel.

6. Wherever the rays that come from all the points of an object, meet again in

* It appears, by aſtronomical obſervations, that the rays of light are 8 minutes and 13 ſeconds in coming from the ſun to the earth, which is diſtant about 82 millions of miles; their progreſs, therefore, is at the rate of about ten millions of miles in a minute; yet great as that velocity is, the diſtance of the neareſt of the fixed ſtars being four hundred thouſand times greater than that of the ſun, the light muſt be more than ſix years in coming from them to us.

ſo many points, after they have been made to converge by refraction or reflection, they will there form an image of that object on any white body.

7. Every object ſeen by refraction or reflection, appears to be in that point from whence its rays are laſt refracted or reflected to the eye.

8. The apparent magnitude of any object is determined by the magnitude of its optic angle: therefore the objects A B and CD, (Plate I. Fig. 2.) which are ſeen under the ſame angle, will appear of equal magnitude.

Theſe, and every other aphoriſm in this part, are confirmed by all optical writers; and may be demonſtrated geometrically: but as we ſuppoſe our readers to have no other previous knowledge than that of common arithmetic, it would be ſuperfluous to inſert ſuch demonſtrations here.

DIOPTRICS.

DIOPTRICS, as we have ſaid, explain the ſeveral appearances that ariſe from the refraction of light.

DEFINITIONS.

1. When a ray of light paſſing out of one medium into another of a different denſity, is turned from that ſtrait line in which it would otherwiſe proceed, into one of a different direction, it is ſaid to be refracted. Thus the ray AB, (Plate I. Fig. 3.) by paſſing out of air into the glaſs GH, is turned from its natural courſe into that of CD.

2. Any ſpherical tranſparent glaſs that converges or diverges the rays of light as they paſs through it, is called a lens.

3. Of lenſes there are five ſorts: 1. A plane or ſingle convex lens, which is plane on one ſide, and convex on the other, as A (Plate I. Fig. 4.) 2. A double convex lens, as B. 3. A plano-concave lens,

that is plane on one ſide and concave on the other, as C. 4. A double concave, as D. And, 5. A meniſcus, which is convex on one ſide and concave on the other, as E.

4. The point C, round which the ſpherical ſurface of a lens, as A Z (Plate I. Fig. 4.) is deſcribed, is called its center: the line X Y, drawn from that center perpendicular to its two ſurfaces, is the axis; and the point V, to which the axis is drawn, is the vertex of that lens.

5. When the rays of light that paſs through a ſingle or double convex lens are brought into their ſmalleſt compaſs, that point is the focus of the lens.

6. In optical inſtruments that lens which is next the object is called the object-glaſs; and that next the eye, the eye-glaſs.

7. The diſtance between the line A B (Plate I. Fig. 3.) and the perpendicular E B, is called the angle of incidence; and the diſtance between the line CD and the perpendicular B F, is called the angle of refraction.

APHO-

APHORISMS.

1. A ray of light paſſing obliquely out of one medium into another that is denſer, will be refracted toward the perpendicular, as the ray AB (Plate I. Fig. 3.) by paſſing out of air into glaſs is refracted into C D, toward the perpendicular B F. On the contrary, a ray paſſing out of a denſer into a rarer medium, will be refracted from the perpendicular; as the ray C D, paſſing out of glaſs into air, is refracted into D I.

2. The angles of incidence, and refraction, when the lines that contain them are all equal, will have a determinate proportion to each other, in the ſame mediums: which between air and water will be as 4 to 3; between air and glaſs, as 3 to 2, nearly; and in other mediums in proportion to their denſities.

3. When an object is viewed through a glaſs whoſe two ſurfaces are parallel, it will appear of its natural dimenſions, its ſituation only being a ſmall matter altered

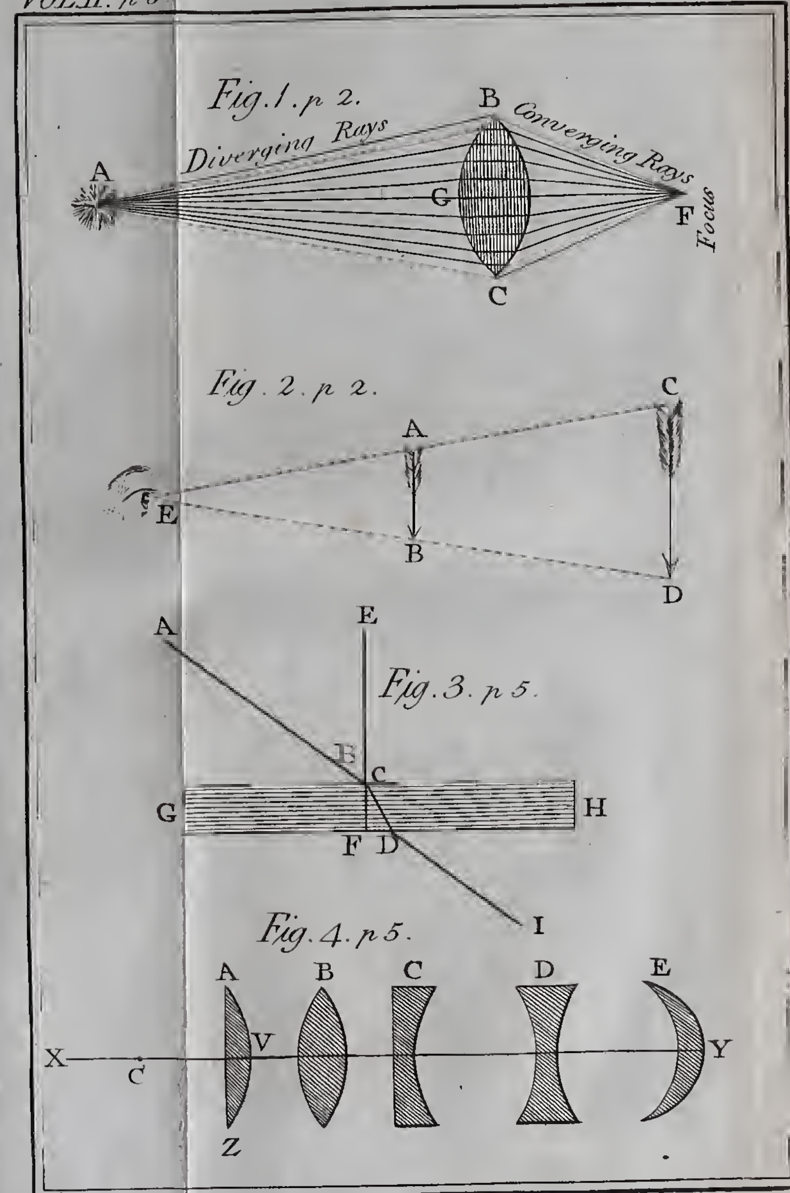
in proportion to the thicknefs of the glafs, and the obliquity of the rays.

4. All the rays of light, whether diverging, parallel, or converging, that fall on a fingle or double convex lens, will meet in a focus behind the glafs; and the diftance of that focus will be greateft in diverging, and leaft in converging rays.

5. When parallel or converging rays, fall on a fingle or double concave lens, they will diverge behind it. If they be diverging at their incidence, they will become more fo by paffing through it.

6. When an object is viewed through two convex lenfes, its apparent length, or diameter, will be to its real length, as the diftance of the focus of the object-glafs, is to that of the eye-glafs.

By thefe, and the foregoing aphorifms, we are enabled to account for the various effects of dioptric machines, as refracting telefcopes, microfcopes, the camera obfcura, &c. For example, fuppofe A B the object glafs, and C D the eye-glafs of a te-



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a telefcope, (Plate II. Fig. 1.) and let them be fo placed that the focus of each may coincide in the point E. Suppofe OI to be a far diftant object, whofe rays are therefore to be confidered as parallel when they come to the glafs, (aphorifm 5. page 3.) the two rays OA, and IB, proceeding from the extremities of the object, and paffing through the glafs A B, will meet and interfect each other in its focus E, and pafs on to the eye-glafs CD. But E being alfo the focus of that glafs, thofe rays, by paffing it, will again become parallel, and therefore by (aphorifm 4. p. 3.) produce diftinct vifion in the eye, placed at H.

Now fuppofe the diftance between AB and E, that is the focal length of the object-glafs, to be ten feet, or 120 inches, and the diftance between E and CD, which is the focal length of the eye-glafs, to be three inches, then, by aphorifm 6. p. 8. the apparent length or diameter of the object will be to its real length as 120 to 3,

or

or as 40 to 1, that is, its length will be magnified 40 times, and consequently its surface, if it be a square, 1600 times.

It is evident, from the construction of this telescope, that the object must appear to the eye inverted, but as it is principally intended for viewing celestial objects, that circumstance is not much regarded. But when it is applied to terrestrial views, two other glasses are added. One of which as E F, (Plate II. Fig. 2.) is placed at twice its focal distance from CD, and the other, G H, at the same distance from that. Now the rays being made to intersect each other again, as is evident from the figure, the object will then appear in its natural position.

Terrestrial telescopes are sometimes made with one object-glass, and one concave eye-glass; but as only a small part of an object can be seen by these at one view, they are of little use, except in near or large objects.

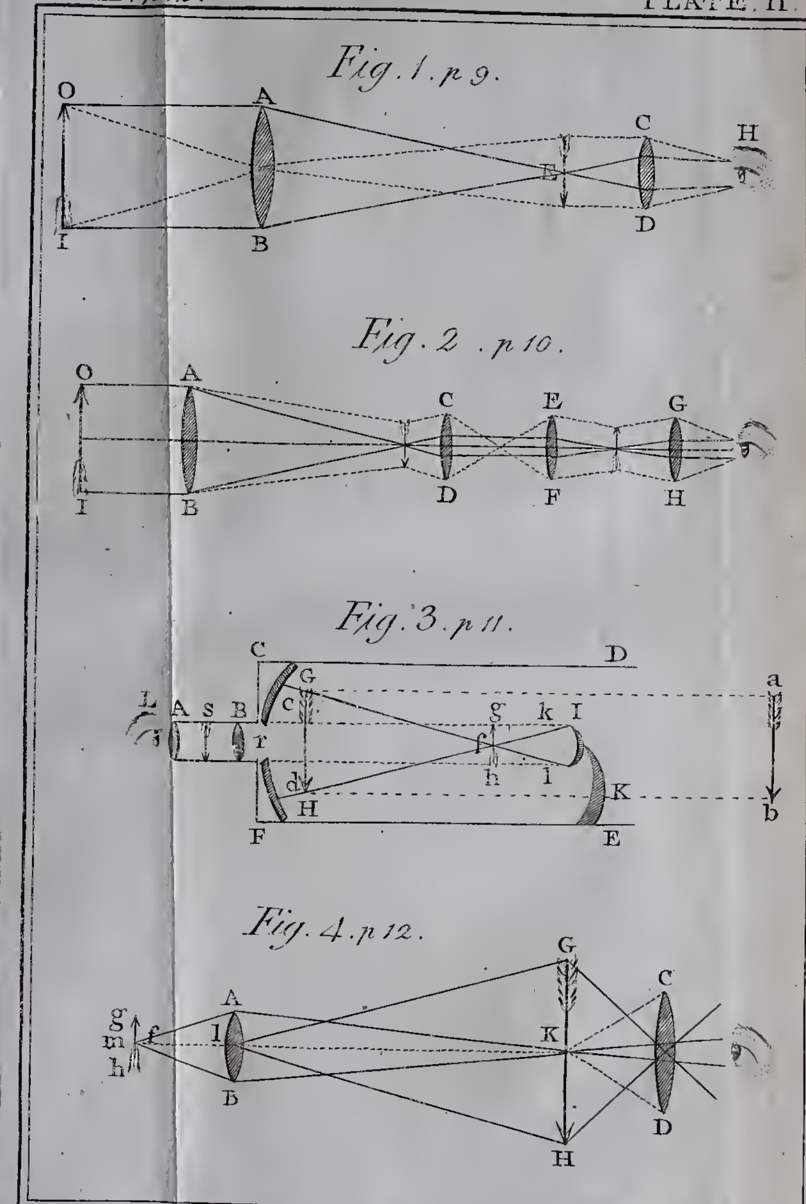
In

In like manner ſuppoſe ABCDEF (Plate II. Fig. 3.) to be the tube of a reflecting teleſcope, the end DE of which is open: let GH be a large concave metalline mirror, perforated at *r*. I, a ſmaller mirror, placed on the ſtand K. Theſe mirrors are to be ſo diſpoſed that the focus of each may fall on the point *f*. Now the image of an object, as *a b*, entering the tube at DE, will fall upon the mirror GH in the points *c d*, and being reflected from thence to the focus *f*, the rays will there interſect each other, and invert the image at *g h*. This image being alſo in the focus of the mirror I, after falling on it in the points *k l*, will be reflected back in parallel rays, which paſſing through the hole *r* in the great mirror, and falling on the convex lens at B, will again croſs each other in the focus of that glaſs at *s*, which being alſo the focus of the lens at A, it will from thence be viewed by the eye at L. The principal excellence of reflecting teleſcopes ariſes from the brightneſs of the

the reflection, by which objects appear ſo diſtinct that an eye-glaſs of a much ſmaller focus can be uſed in them than in others. The magnifying power in this, as in other teleſcopes, is as the focal diſtance of the object-glaſs or mirror, to the focal diſtance of the eye-glaſs. But the latter being ſo much ſmaller in this teleſcope, the magnifying power will be ſo much greater. Therefore, if the focal diſtance of the eye-glaſs be one inch, and that of the object mirror 40 inches, the diameter of the object will be magnified 40 times, and its ſurface 1600 times. A reflecting teleſcope of 4 feet will magnify more than a refractor of 50 feet.

Suppoſe, again, AB (Plate II. Fig. 4.) to be the object-glaſs, and C D the eye-glaſs of a double microſcope. The object-glaſs muſt here be quite ſmall and very convex, and conſequently its focal diſtance *l f*, very ſhort. The diſtance of the ſmall object *g m h*, muſt be very little more

VOL. II. p. 12. PLATE. II.



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more than that of $l\ f$, in order that its image GH, may be formed at a conſiderable diſtance, and conſequently be much enlarged. Now this image will appear diſtinct and conſiderably magnified, and that on two accounts: firſt, in proportion as the diſtance K l is greater than $l\ m$; and ſecondly, on account of the nearneſs of the eye to the image; for by aphoriſm 3. page 3. no object can be ſeen diſtinctly by the naked eye, at a leſs diſtance than eight inches, therefore if by means of the eye-glaſs CD, the object is made to appear diſtinct at the diſtance of one inch, it will ſeem eight times as large. Suppoſing, therefore, the focal diſtance of the eye-glaſs CD, to be one inch, and the diſtance K l to be to $l\ m$ as ten to 1, then, on both theſe accounts, the length of the object will appear 8 times 10, or 80 times, and it, ſurface 6400 times, larger than when ſeen by the naked eye.

RECREATION I.

Optical illusions.

ON the bottom of the veſſel A B C D, (Plate III. Fig. 1.) place three pieces of money, as a ſhilling, a half-crown, and crown; the firſt at E, the ſecond at F, and the laſt at G. Then place a perſon at H, where he can ſee no farther into the veſſel than I: and tell him that by pouring water into the veſſel you will make him ſee three different pieces of money; bidding him obſerve carefully whether any money goes in with the water*.

When the water comes up to K, the piece at E will become viſible; when it comes up to L, the pieces at E and F will appear; and when it riſes to M, all the three pieces will be viſible.

* You muſt either pour it in very gently, or contrive to fix the pieces, that they may not move out of their places by the motion of the water.

From

From what has been ſaid of the refraction of light, the cauſe of this phenomenon will be evident: for while the veſſel is empty, the ray H I will naturally proceed in a ſtraight line: but in proportion as it becomes immerſed in water, it will be neceſſarily refracted into the ſeveral directions NE, OF, PG, and conſequently the ſeveral pieces muſt become viſible.

RECREATION II.

Optical augmentation.

TAKE a large drinking glaſs of a conical figure, that is, ſmall at bottom and wide at top; in which put a ſhilling, and fill the glaſs about half full with water: then place a plate on the top of it, and turn it quickly over, that the water may not get out. You will then ſee on the plate, a piece of the ſize of a half crown; and ſomewhat higher up, another piece of the ſize of a ſhilling.

This

This phenomenon arifes from feeing the piece through the conical furface of the water at the fide of the glafs, and through the flat furface at the top of the water, at the fame time: for the conical furface dilates the rays and makes the piece appear larger; but by the flat furface the rays are only refracted, by which the piece is feen higher up in the glafs, but ftill of its natural fize. That this is the caufe will be farther evident by filling the glafs with water, for as the fhilling cannot be then feen from the top, the large piece only will be vifible.

After you have amufed yourfelf with this remarkable phenomenon, you may give the glafs to a fervant, telling him to throw out the water, and take care of the two pieces of money; and if he have no fufpicion of the deception, he will be not a little furprifed to find one piece only.

RECRE-

RECREATION III.

Optical ſubtraction.

AGAINST the wainſcot of a room fix three ſmall pieces of paper, as A, B, C, (Pl. III. Fig. 2.) at the height of your eye; and placing yourſelf directly before them, at a few yards diſtance, ſhut your right eye and look at them with the left; when you will ſee only two of thoſe papers, ſuppoſe A and B; but altering the poſition of your eye you will then ſee the third and one of the firſt, ſuppoſe A; and by altering your poſition a ſecond time, you will ſee B and C; but never all three of them together.

The cauſe of this phenomenon is, that one of the three pencils of rays that come from theſe objects, falls on the optic nerve at D; whereas to produce diſtinct viſion it is neceſſary that the rays of light fall on ſome part of the retina E, F, G, H. We

We ſee by this experiment, one of the uſes of having two eyes; for he that has one only, can never ſee three objects placed in this poſition, nor all the parts of one object of the ſame extent, without altering the ſituation of his eye.

RECREATION XI.

Alternate illuſion.

WITH a convex lens of about an inch focus, look attentively at a ſilver ſeal, on which a cypher is engraved. it will at firſt appear cut in, as to the naked eye; but if you continue to obſerve it ſome time, without changing your ſituation, it will ſeem to be in relief, and the lights and ſhades will appear the ſame as they did before. If you regard it with the ſame attention ſtill longer, it will again appear to be engraved: and ſo on alternately.

If you look off the ſeal for a few moments, when you view it again, in-
ſtead

ſtead of ſeeing it, as at firſt, engraved, it will appear in relief.

If, while you are turned toward the light, you ſuddenly incline the ſeal, while you continue to regard it, thoſe parts that ſeemed to be engraved will immediately appear in relief: and if, when you are regarding theſe ſeeming prominent parts, you turn yourſelf ſo that the light may fall on the right hand, you will ſee the ſhadows on the ſame ſide from whence the light comes, which will appear not a little extraordinary. In like manner the ſhadows will appear on the left, if the light fall on that ſide. If inſtead of a ſeal you look at a piece of money, theſe alterations will not be viſible, in whatever ſituation you place yourſelf*.

* It has been ſuſpected that this illuſion ariſes from the ſituation of the light; and in fact I have obſerved (ſays M. Guyot, from whom this article is taken) that when I have viewed it with a candle on the right, it has appeared engraved, but by changing the light

RECREATION V.

The camera obſcura, or dark chamber.

WE ſhall here give a ſhort deſcription of this optical invention; for though it is very common, it is alſo very pleaſing, and though almoſt every one has ſeen it, every one knows not how to conſtruct it.

light to the left ſide, it has immediately appeared in relief. It ſtill, however, remains to be explained, why we ſee it alternately hollow and prominent, without changing either the ſituation or the light. Perhaps it is in the ſight itſelf that we muſt look for the cauſe of this phenomenon; and this ſeems the more probable, as all theſe appearances are not diſcernible by all perſons.

A phenomenon like this will appear to a ſuperficial obſerver a very trifling matter: but the philoſopher, who is deſirous of explaining all the appearances of nature, will find it attended with no trifling difficulties. It is, moreover, by inveſtigating the cauſes of phenomena ſeemingly inſignificant, that the moſt important diſcoveries are ſometimes made.

Make a circular hole in the ſhutter of a window, from whence there is a proſpect of the fields, or any other object not too near; and in this hole place a convex glaſs, either double or ſingle, whoſe, focus is at the diſtance of five or ſix feet*. Take care that no light enter the room but by this glaſs: at a diſtance from it, equal to that of its focus, place a paſteboard, covered with the whiteſt paper †; let it be two feet and a half long, and eighteen or twenty inches high: bend the length of it inwards, to the form of part of a circle, whoſe diameter is equal to double the focal diſtance of the glaſs. Then fix it on a

* The diſtance ſhould not be leſs than three feet; for if it be, the images will be too ſmall, and there will not be ſufficient room for the ſpectators to ſtand conveniently. On the other hand the focus ſhould never be more than 15 or 20 feet, for then the images will be obſcure, and the colouring faint. The beſt diſtance is from 6 to twelve feet.

† This paper ſhould have a black border, to prevent any of the ſide rays from diſturbing the picture.

frame of the ſame figure, and put it on a moveable foot, that it may be eaſily fixed at that exact diſtance from the glaſs where the objects paint themſelves to the greateſt perfection. When it is thus placed, all the objects that are in the front of the window will be painted on the paper, in an inverted poſition *, with the greateſt regularity and in the moſt natural colours.

If you place a moveable mirror without the window, by turning it more or leſs,

* This inverted poſition of the images may be deemed an imperfection, but it is eaſily remedied: for if you ſtand above the board on which they are received, and look down on it, they will appear in their natural poſition: or if you ſtand before it, and placing a common mirror againſt your breaſt in an oblique direction, look down in it, you will there ſee the images erect, and they will receive an additional luſtre from the reflection of the glaſs; or place two lenſes, in a tube that draws out; or, laſtly, if you place a large concave mirror at a proper diſtance before the picture, it will appear before the mirror, in the air, and in an erect poſition.

you

you will have on the paper all the objects that are on each side of the window*.

If instead of placing the mirror without the window you place it in the room, and above the hole (which must then be made near the top of the shutter), you may receive the representation on a paper placed horizontally on a table; and draw at your leisure, all the objects that are there painted.

Nothing can be more pleasing than this Recreation, especially when the objects are strongly enlightened by the sun: and

* There is another method of making the dark chamber, which is by a scioptric ball, that is, a ball of wood, through which a hole is made, in which hole a lens is fixed: this ball is placed in a wooden frame, in which it turns freely round. The frame is fixed to the hole in the shutter, and the ball, by turning about, answers, in great part, the use of the mirror on the outside of the window. If the hole in the window be no bigger than a pea, the objects will be represented without any lens.

not only land profpects, but a fea-port, when the water is fomewhat agitated, or at the fetting of the fun, prefents a very delightful appearance.

This reprefentation affords the moft perfect model for painters, as well for the tone of colours, as that degradation of fhades, occafioned by the interpofition of the air, which has been fo juftly expreffed by fome modern painters.

It is neceffary that the paper have a circular form, for otherwife, when the center of it was in the focus of the glafs, the two fides would be beyond it, and confequently the images would be confufed. If the frame were contrived of a fpherical figure, and the glafs were in its center, the reprefentation would be ftill more accurate. If the object without be at the diftance of twice the focal length of the glafs, the image in the room will be of the fame magnitude with the object.

The

The lights, ſhades, and colours in the camera obſcura appear not only juſt, but, by the images being reduced to a ſmaller compaſs, much ſtronger than in nature: add to this, that theſe pictures exceed all others by repreſenting the motion of the ſeveral objects: thus we ſee the animals walk, run, or fly, the clouds float in the air, the leaves quiver, the waves roll, &c. and all in ſtrict conformity to the laws of nature. The beſt ſituation for a dark chamber is directly north, and the beſt time of the day is noon.

RECREATION VI.

To ſhew the ſpots on the ſun's diſk, by its image in the camera obſcura.

PUT the object-glaſs of a ten or twelve foot teleſcope into the ſcioptric ball and turn it about till it be directly oppoſite the ſun*. Then place the paſteboard, mentioned

* When the ſun is directly oppoſite the hole the lens will itſelf be ſufficient: or by means of the

mentioned in the laſt Recreation, in the focus of the lens, and you will ſee a clear bright image of the ſun, of about an inch diameter, in which the ſpots on the ſun's ſurface will be exactly deſcribed.

As this image is too bright to be ſeen with pleaſure by the naked eye, you may view it through a lens, whoſe focus is 6 or 8 inches diſtant, which at the ſame time that it prevents the light from being offenſive, will, by magnifying both the image and the ſpots, make them appear to greater advantage.

the mirror on the outſide of the window, as in the fifth Recreation, the lens will anſwer the purpoſe at any time.

RECRE-

RECREATION VII.

To magnify ſmall objects by means of the ſun's rays let it into a dark chamber.

LET the rays of light that paſs through the lens in the ſhutter be thrown on a large concave mirror, properly fixed in a frame. Then take a ſlip, or thin plate of glaſs, and ſticking any ſmall object on it, hold it in the incident rays, at a little more than the focal diſtance from the mirror, and you will ſee, on the oppoſite wall, amidſt the reflected rays, the image of that object, very large, and extremely clear and bright. This experiment never fails to give the ſpectator the higheſt ſatisfaction.

RECREATION VIII.

The portable camera obſcura.

THE great pleaſure produced by the camera obſcura in the common form has excited ſeveral to render it more univerſally uſeful by making it portable; eaſily fixed on any ſpot, and adapted to every proſpect. We ſhall not here examine the merits of the various ſorts that have been invented, among which there are doubtleſs ſeveral highly ingenious; but content ourſelves with deſcribing one that may have ſome advantages not to be found in others.*.

Let ABCD (Pl. III. Fig. 3.) be a frame of wood, of two feet long and about twenty inches wide; let its four ſides be two inches and a half thick, and firmly joined together. In a groove formed in this

* This ſort of portable camera appears to be the invention of M. Guyot.

frame

frame place a plate of clear glaſs, E *. To each of the corners of this frame join a leg, with a hinge, that it may turn up, under the table. To the under part of the frame join four pieces of light wood, as H, which muſt alſo have hinges to fold up; and obſerve that when they are let down, as in the figure, they muſt cloſely join, by means of hooks, it being quite neceſſary that no light enter the box †.

To that juſt deſcribed, there muſt be added a ſmaller box M, in which muſt be an inclined mirror N, and in one of its ſides a moveable tube O, five or ſix inches long. This tube muſt be furniſhed with a convex glaſs, the focus of which, by the reflection of the mirror, muſt reach the glaſs E in the frame.

* If the upper ſide of the glaſs were convex, it would be ſtill better.

† The inſide of the box may be lined with black cloth, to make it as dark as poſſible.

There

There muſt alſo be a covering of black ſtuff, in form of a tent, to place over the top of the frame, by means of four little poles that go into holes in the corners of it. There muſt be an opening to this tent on the ſide A B, by a curtain to be drawn up, and which you are to let down over you, when you place yourſelf under it; that no light may enter. The three other ſides ſhould hang down ſome inches over the frame.

This camera is, indeed, ſomething more cumberſome than thoſe that have been hitherto invented; and yet, if properly made, it will not weigh more than twenty to five-and-twenty pounds. On the other hand, it is much more convenient; for as the coloured rays of objects paint themſelves on the bottom of the glaſs in the frame, you may draw them without having your hand between the rays and their image.

When

When you have placed the frame on a ſpot a little elevated, that nothing may intercept the rays from falling on the glaſs in the tube, you fix a ſheet of tranſparent varniſhed paper on the glaſs in the frame, by means of wax at its corners. Then placing yourſelf under the curtain, you trace on the paper all the outlines of the objects there repreſented, and if you think fit, you may alſo mark the extent of the ſhadows. If you want only the outlines, you may lay a thin plate of glaſs on that in the frame, and trace the ſtrokes with a pencil and carmine. After which you muſt dip a ſheet of paper in water, without making it too wet, and ſpreading it lightly over that glaſs, you will have the impreſſion of the deſign there drawn.

Note, By each of theſe methods you will have the objects either in their natural poſition, or reverſed: which will be an advantage when the deſign is to be engraved, and you will have it then appear in the natural poſition.

In uſing this machine, you ſhould make choice of thoſe objects on which the ſun then ſhines, as the appearances of the ſhadows adds greatly to the beauty of the deſign. There are, however, circumſtances in which it is to be avoided, as when you would paint a riſing or ſetting ſun, &c.

RECREATION IX.

The magic lantern.

THIS very remarkable machine, which is now known over all the world, cauſed great aſtoniſhment at its origin. It is ſtill beheld with pleaſing admiration, and the ſpectator very frequently contents himſelf with wondering at its effects, without endeavouring to inveſtigate their cauſe. The invention of this ingenious illuſion is attributed to the celebrated P. Kircher, who has publiſhed, on various ſciences, works equally learned, curious, and entertaining.

The

The defign of this machine is to reprefent at large, on a cloth or board, placed in the dark, the images of fmall objects, painted with tranfparent colours on plates of glafs.

Its conftruction is as follows. Let ABCD (Pl. III. Fig. 4.) be a tin box, eight inches high, ten long, and fix wide (or any other fimilar dimenfions.) At the top muft be a funnel E, of four inches in diameter, with a cover F, which, at the fame time that it gives a paffage to the fmoke, prevents the light from coming out of the box.

On the fide AC there is a door, by which is adjufted a concave mirror G, of metal or tin, and of five inches diameter; being part of a fphere whofe diameter is eighteen inches, this mirror muft be fo difpofed that it may be pufhed forward or drawn back by means of the handle H, that enters

 the

the tin tube I, which is ſoldered to the door.

In the middle of the box muſt be placed a low tin lamp K, which is to be moveable. It ſhould have three or four lights, that muſt be at the height of the focus of the mirror G.

In the ſide BD, and oppoſite to the mirror, there muſt be an aperture of three inches wide and two inches and a half high, in which is to be fixed a convex glaſs L, of the ſame dimenſion*, whoſe focus muſt be from four inches and a half to five inches, ſo that the lamp may be

* I prefer this form for the glaſs (ſays M. Guyot) that the picture thrown upon the cloth may have the ſame form, which is much preferable to a circular aperture, through which the figures can never be completely ſeen out when they are at the center of the glaſs. It is ſurpriſing that this imperfection has been ſuffered to continue ſo long, when it is ſo eaſily remedied.

placed

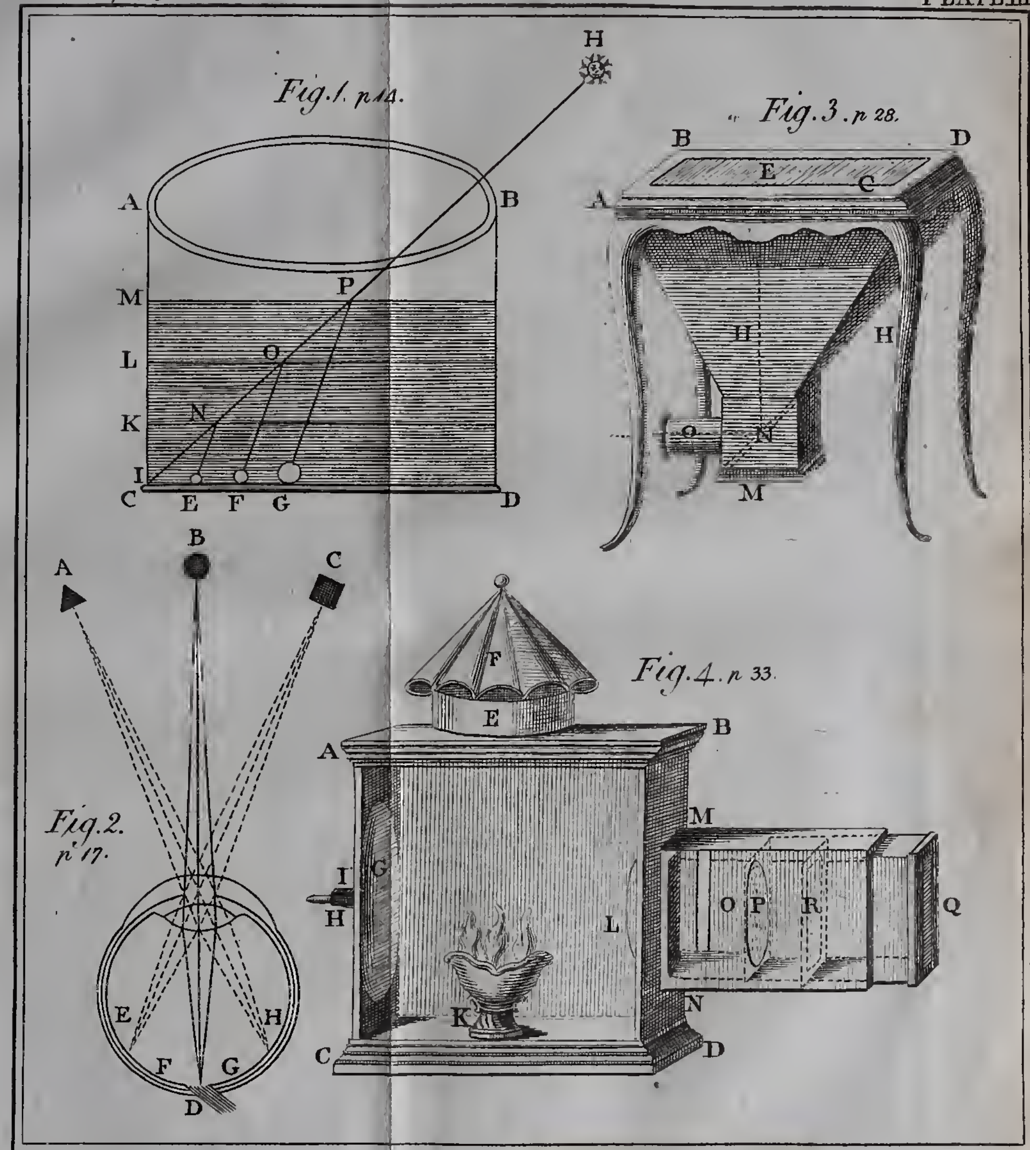
placed both in its focus, and in that of the concave mirror.

On the ſame ſide place a piece of tin M N, of four inches and a half ſquare, having an opening at the ſides of about four inches and a half high, and a quarter of an inch wide. Through this opening or groove are to paſs the glaſſes, on which are painted the figures that are to be ſeen on the cloth. In this tin piece, and oppoſite the glaſs L, let there be an aperture of three inches and a quarter long, and two inches and a quarter high, to which muſt be adjuſted a tube O, of the ſame form, and ſix inches long. This tube is to be fixed into the piece M N. Another tube, ſix inches long, and moveable, muſt enter that juſt mentioned, in which muſt be placed two convex lenſes, P and Q; that of P may have a focus of about three inches, and that of Q, which is to be placed at the extremity of the tube, one of ten or twelve inches. The diſtance

between thefe glaffes is to be regulated by their foci. Between thefe glaffes there muft be placed a pafteboard R, in which is an aperture of an inch wide, and 4-5ths of an inch high. By placing this tube farther in or out of the other, the images on the cloth will appear larger or fmaller.

From what has been faid of the preceding machines, the conftruction of this will be eafily underftood. The foci of the concave mirror, and the lens L, meeting in the flame of the lamp, they together throw a ftrong light on the figures painted on the glaffes that pafs through the groove M N, and by that means render their colours diftinct on the cloth. The rays from thofe glaffes paffing through the lens P are collected by the aperture in the pafteboard R, and conveyed to the lens Q, by which they are thrown on the cloth.

The lantern being thus adjufted, you muft provide plates of clear glafs, of twelve



J. Lodge sculp.

or fifteen inches long, and three inches wide, which are to be placed in thin frames, that the may pafs freely through the groove M N, after being painted in the manner we fhall now defcribe.

Method of painting the glaffes for the lantern.

Draw on a paper the fubject you intend to paint, and fix it at each end to the glafs. Provide a varnifh with which you have mixed fome black paint, and with a fine pencil draw on the other fide of the glafs, with very light touches, the defign drawn on the paper. If you are defirous of making the painting as perfect as poffible, you fhould draw fome of the outlines in their proper colours, provided they are the ftrongeft tints of thofe colours that are ufed. When the outlines are dry, you colour the figures with their proper tints or degradations; and thofe colours will not peel off, if you temper them with a

ſtrong white varniſh*, You are then to ſhade them with black mixed with the ſame varniſh, or white biſtre, as you find convenient. You may alſo leave ſtrong lights in ſome parts, without any colours, in order to produce a more ſtriking effect. Obſerve, in particular, not to uſe more than four or five colours, ſuch as blue, red, green and yellow. You ſhould employ however a great variety of tints, to give your painting a more natural air, without which they will repreſent vulgar objects, which are by no means the more pleaſing becauſe they are gaudy.

When the lamp in this lantern is lighted, and by drawing out the tube to a proper length, the figures painted on the glaſs appear bright and well defined, the ſpectator cannot fail of being highly enter-

* All thoſe colours that are not terreſtrial, as Pruſſian blue, carmine, calcined verdigris, &c. may be uſed to advantage, when tempered with a proper varniſh.

tained

tained by the ſucceſſion of natural or groteſque figures that are painted on the glaſſes.

This piece of optics may be rendered much more amuſing, and at the ſame time more marvellous, by preparing figures to which different natural motions may be given*, which every one may perform according to his own taſte; either by movements in the figures themſelves, or by painting the ſubject on two glaſſes, and paſſing them at the ſame time through the groove, as will be ſeen in the next Recreation.

* There are in the Philoſophical Eſſays of M. Muſchenbroek, different methods of performing all theſe various movements, by ſome mechanical contrivances that are not difficult to execute.

RECREATION X.

To represent a tempest, by the magic lantern.

PROVIDE two plates of glass, whose frames are so thin that they may both pass freely through the groove of the lantern at the same time.

On one of these glasses you are to paint the appearance of the sea, from the slightest agitation to the most violent commotion. Representing from A to B (Pl. IV. Fig. 1.) a calm; from B to C a small agitation, with some clouds; and so on to F and G, which should exhibit a furious storm. Observe that these representations are not to be distinct, but run into each other, that they may form a natural gradation; remember also, that great part of the effect depends on the perfection of the painting, and the picturesque appearance of the design.

On the other glass (Fig. 2.) you are to paint vessels of different forms and dimensions,

ſions, and in different directions, together with the appearance of clouds in the tempeſtuous parts.

You are then to paſs the glaſs (Fig. 1.) ſlowly through the groove, and when you come to that part where the ſtorm begins, you are to move the glaſs gently up and down, which will give it the appearance of a ſea that begins to be agitated; and ſo increaſe the motion till you come to the height of the ſtorm At the ſame time you are to introduce the other glaſs with the ſhips, and moving that in like manner, you will have a natural repreſentation of the ſea and of ſhips in a calm and in a ſtorm. As you draw the glaſſes ſlowly back, the tempeſt will ſeem to ſubſide, the ſky grow clear, and the ſhips glide gently over the waves.

This effect of the magic lantern muſt certainly afford more pleaſure and ſurprize, than to ſee figures, frequently badly painted,

painted, appear one after the other in the midst of a luminous circle, as in a medal; whose form, besides being disgustful, prevents you from seeing any two figures, together, without the head and legs of one of them being entirely hid: an inconvenience that is avoided by this new method, even when you make use of the common figures.

By means of two glasses disposed in this manner you may likewise represent a battle, or sea fight, and numberless other subjects, that every one will contrive according to his own taste. They may be also made to represent some remarkable or ludicrous action between different persons, and many other amusements that a lively imagination will easily suggest. The instance we here give (says M. Guyot) being intended merely as an example, and to shew that this machine is capable of producing much more remarkable effects than have been hitherto exhibited.

RECREATION XI.

The nebulous magic lantern.

THE light of the magic lantern, and the colour of images, may not only be painted on a cloth, but alſo reflected by a cloud of ſmoke.

Provide a box of wood or paſteboard AB (Pl. IV. Fig. 3.) of about four feet high, and of ſeven or eight inches ſquare at bottom, but diminiſhing as it aſcends, ſo that its aperture at top is but ſix inches long, and half an inch wide. At the bottom of this box there muſt be a door that ſhuts quite cloſe, by which you are to place in the box a chafing-diſh with hot coals, on which is to be thrown incenſe, whoſe ſmoke goes out in a cloud at the top of the box. It is on this cloud that you are to throw the light that comes out of the lantern, and which you bring into a ſmaller compaſs by drawing out the moveable

tube.

tube. The common figures will here ferve. It is remarkable in this reprefentation, that the motion of the fmoke does not at all change the figures, which appear fo confpicuous that the fpectator thinks he can grafp them with his hand.

Note, In this experiment fome of the rays paffing through the fmoke the reprefetation will be much lefs vivid than on the cloth ; and if care be not taken to reduce the light to its fmalleft focus, it will be ftill more imperfect.

RECREATION XII.

To produce the appearance of a phantom, upon a pedeftal placed on the middle of a table.

ENCLOSE a common fmall magic lantern in a box A B C D (Plate IV. Fig. 4,) that is large enough to contain alfo an inclined mirror M, which muft be moveable, that it may reflect the cone

cone of light thrown on it by the lantern, in ſuch manner that it may paſs out at the aperture made in the top of the box. There ſhould be a flap with hinges to cover the opening, that the inſide of the box may not be ſeen when the experiment is not making. This aperture ſhould likewiſe be oval, and of a ſize adapted to the cone of light that is to paſs through it.

There muſt be holes made in that part of the box which is over the lantern, to let out the ſmoke; and over that part muſt be placed a chafing-diſh of an oblong figure, and large enough to hold ſeveral lighted coals *.

There muſt alſo be a glaſs that will aſcend and deſcend at pleaſure in the vertical groove *a b*. To this glaſs let there be

* This chafing-diſh may be encloſed in a painted tin box of about a foot high, with an aperture at top ſomething like Fig. 3. It ſhould ſtand on four ſhort feet, to give room for the ſmoke of the lamp to paſs out.

fixed

fixed a cord, that, going over a pulley *c*, paſſes out of the box at the ſide CD, by which the glaſs may be drawn up, and will deſcend by its own weight.

On this glaſs may be painted a ſpectre, or any other more pleaſing figure. Obſerve that the figures muſt be contracted in drawing, as the cloud of ſmoke does not cut the cone of light at right angles, and therefore the figures will appear longer than they do on the glaſs.

After you have lighted the lamp in the lantern, and put the mirror in a proper direction, you place the box or pedeſtal ABCD on a table, and putting the chafing-diſh in it, throw ſome incenſe in powder on the coals. You then open a trap door, and let down the glaſs ſlowly; and when you perceive the ſmoke diminiſh you draw up the glaſs, that the figure may diſappear, and ſhut the trap door. This appearance will occaſion no ſmall ſurprize, as the ſpectre

ſpectre will ſeem to riſe gradually out of the pedeſtal, and on drawing up the glaſs will diſappear in an inſtant. Obſerve, that when you exhibit this Recreation you muſt put out all the lights in the room; and the box ſhould be placed on a high table, that the ſpectators may not perceive the aperture by which the light comes out. Tho' we have mentioned a ſmall magic lantern, yet the whole apparatus may be ſo enlarged, that the phantom may appear of a formidable ſize.

By having glaſſes properly painted, you may alſo produce the image of a flower, or a card, &c. like one you have burnt, and caſt the aſhes into the fire with the incenſe, and by that means pretend to make the image riſe out of the aſhes; with many other devices that every one may contrive of that kind which ſhall pleaſe him beſt.

RECREATION XIII.

The magical theatre.

BY making ſome few additions to the magic lantern with the ſquare tube*, uſed in the ninth Recreation, various ſcenes, characters, and decorations of a theatre may be lively repreſented.

Let there be made a wooden box ABCD (Plate IV. Fig. 5.) a foot and a half long, fifteen inches high and ten wide. Let it be placed on a ſtand E F, that muſt go round it, and by which it may be fixed with two ſcrews to a table. Place over it a tin cover, as in the common lantern.

Make an opening in its two narroweſt ſides; in one of which place the tube H,

* It is quite neceſſary to make the lantern much larger than common, that the objects painted on the glaſſes, being of a larger ſize, may be repreſented with greater preciſion, and conſequently their ſeveral characters more ſtrongly marked.

and

and in the other the tube I; let each of them be ſix inches wide, and five inches high; in each of theſe tubes place another that is moveable, in order to bring the glaſſes, or concave mirror, that are contained in them, to a proper diſtance; as will be explained hereafter.

In the middle of the bottom of this box place a tin lamp, M, which muſt be moveable in a groove, that it may be placed at a proper diſtance with regard to the glaſſes and mirror: this lamp ſhould have five or ſix lights, each of them about an inch long.

At the beginning of the tube H, toward the part N, make an opening of an inch wide, which muſt croſs it laterally: another of three quarters of an inch, that muſt croſs it vertically, and be nearer the box than the firſt; and a third of half an inch, that muſt be before the firſt.

The opening made laterally muſt have three or four grooves, the ſecond two, and

the third one: that different ſubjects of figures and decorations may be paſſed, either ſideways, aſcending, or deſcending, ſo that the ſcenes of a theatre may be the more exactly imitated*. Encloſe theſe grooves between two convex rectangular glaſſes, of ſix inches long, and five inches high, and of about twenty inches focus; one of which muſt be placed at O, and the other toward P. Have another tube Q, of about a foot long, which muſt enter that marked H; and at its outward extremity place a lens of about fifteen inches focus.

There muſt alſo be a third tube R, four inces long, which is to enter that marked I: to the exterior end of this adjuſt a concave mirror, whoſe focus muſt be at ſeven or eight inches from its reflecting ſurface.

* In the decorations, the clouds and the palaces of the Gods ſhould deſcend; caves and infernal palaces ſhould aſcend; earthly palaces, gardens, &c. enter at the ſides.

This

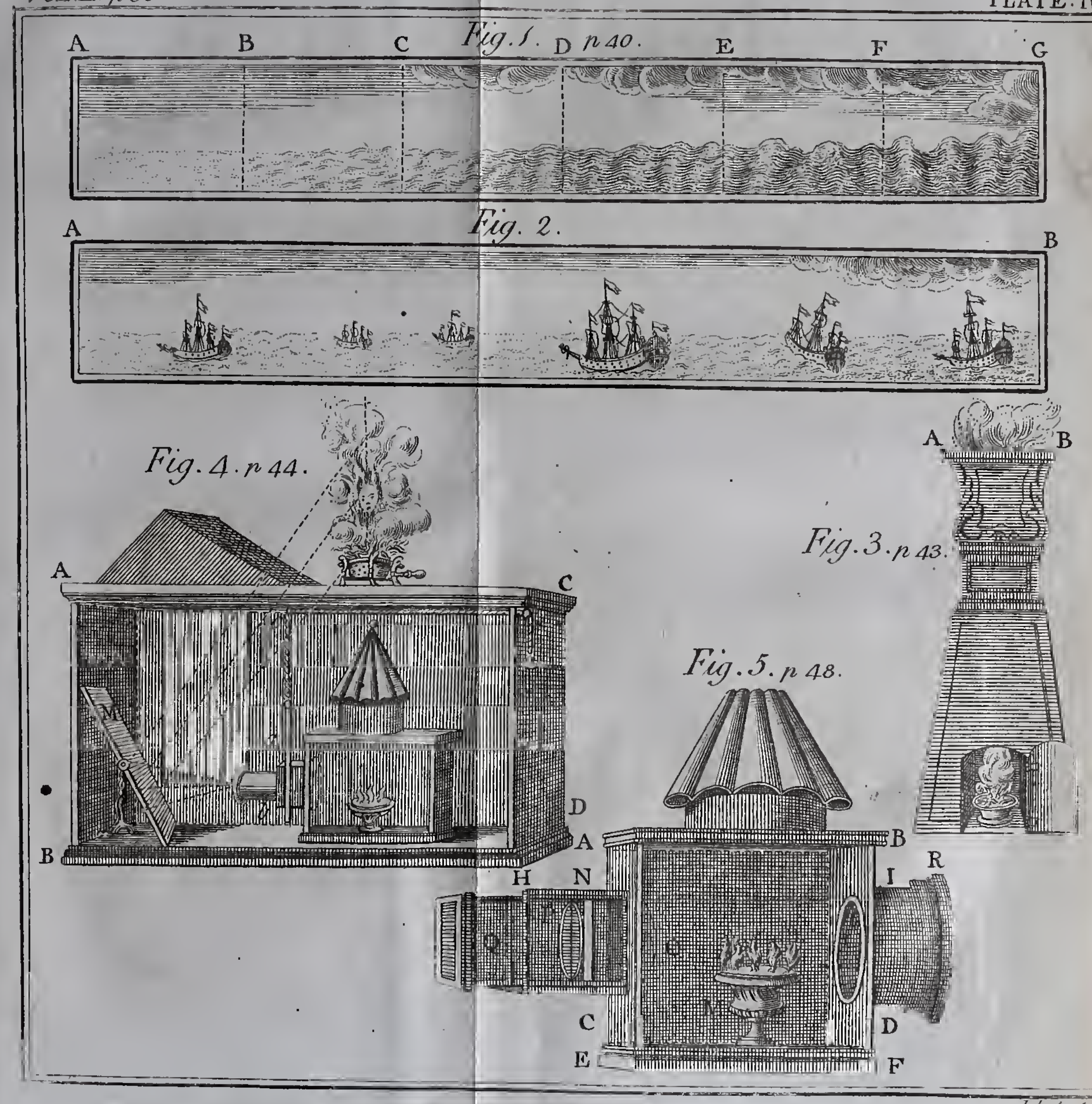


Fig. 1. p 40.
A B C D E F G
Fig. 2.
A B
Fig. 4. p 44.
A C B D
Fig. 3. p 43.
A B
Fig. 5. p 48.
A B H N I R C D E F
J Lodge sculp.

This magic lantern being thus adjuſted, nothing more is neceſſary than to provide glaſſes, painted with ſuch ſubjects as you would repreſent, according to the grooves they are to enter. The lamp is then to be lighted, and placing a glaſs in one of the grooves, you draw out the moveable tubes till the object paints itſelf on a cloth to the moſt advantage: by which you determine the diſtance of the lantern, and the ſize of the image. You then make a hole in the partition of that ſize, and fix in it a plate of clear glaſs, over which you paſte a very thin paper, which muſt be varniſhed, that it it may be as tranſparent as poſſible.

It is on this paper that are to be exhibited the images of all thoſe objects, that by paſſing ſucceſſively through the grooves, are to repreſent a theatric entertainment. This exhibition will be the more agreeable, as the magic lantern being concealed behind the partition, the cauſe of the

 illuſion

illusion cannot by any means be discovered.

In order to show more clearly in what manner a subject of this sort should be painted, and the glasses disposed, we will here make choice of the siege of Troy, for a theatric subject; in which will be found all the incidents necessary to the exhibition of any other subject whatever.

In the first act, the theatre may represent, on one side the ramparts of Troy, toward the back part the Grecian camp, and at a farther distance, the sea and the isle of Tenedos. We will suppose the time to be that when the Greeks feigned to raise the siege, and embarked, leaving behind them the wooden horse, in which were contained the Grecian soldiers.

On a glass, therefore, of the same width with the aperture made in the side AC of the box, you are to paint a deep blue curtain,

tain, lightly charged with ornaments, quite tranſparent. This glaſs is to be placed in the firſt ventricle groove, ſo that by letting it gently down *, its image may appear to riſe in the ſame manner as the curtain of a theatre.

You muſt have ſeveral glaſſes of a proper ſize to paſs through the horizontal grooves, and of different lengths according to the extent of the ſubject. You may paint,

On the firſt the walls of Troy.

On the ſecond the Grecian camp.

On the third, the ſea, the iſle of Tenedos, and a ſerene ſky.

On the fourth, the Grécian troops, by detached figures.

On the fifth, other troops, diſpoſed in battalions, and placed at a diſtance.

* All the glaſſes that are to riſe and deſcend muſt be bordered with thin pieces of wood, and ſo exactly fill the grooves, that they may not ſlide down of themſelves.

On the ſixth, divers veſſels, which, as the glaſs advances in the groove, diminiſh in ſize.

On the ſeventh the wooden horſe and Sinon.

On the eighth, Trojan men and women.

Theſe glaſſes being properly painted *, you place in the horizontal grooves the firſt, ſecond, third, and fourth. Then draw up the curtain, by letting down the glaſs on which it is painted, and draw away gently the fourth glaſs, and after that the ſecond ; then advance, very gently, the fifth, that repreſents the embarkment, and paſs it quite through. Next paſs, the oppoſite way, the ſixth, which repreſents the Grecian fleet. The objects painted on the fourth, fifth, and ſixth quite diſappearing, you are to advance the ſeventh, on which is painted the

* Unleſs you can procure glaſſes well painted, it were better to repreſent ſome comic ſubject, where common paintings may ſuffice.

wooden

wooden horfe, and at the fame time the eighth, where the Trojans will appear to draw the horfe into the city. The curtain is then to be let down, that you may withdraw the fcenes of the firft act, and place in the grooves thofe that are to compofe the fecond.

In the fecond act may be reprefented the interior part of the city of Troy: on one fide may be feen the wooden horfe, and in the back part the temple of Pallas. The glaffes for this act may be painted in the following manner.

On the firft may be palaces and houfes, reprefenting the infide of a city.

On the fecond, the temple of Pallas in the centre, with a clear night and the moon. In the front may be feen the wooden horfe, that the Trojans have placed near the temple of Pallas.

On the third, a troop of Greeks, with Sinon at their head, who are going to

open the gates of the city to the Grecians.

On the fourth, different troops of armed Greeks; painted on a long glafs, to afford variety.

On the fifth, feveral troops of Trojans.

On the fixth, various appearances of fire and fmoke, fo difpofed that this glafs being drawn up above the others, the objects painted on the firft glafs, may appear in a conflagration.

Before you draw up the curtain you fhould place the firft and fecond glaffes. You then pafs the whole third glafs flowly a little after, the fourth, on which are painted the different bodies of armed Greeks, and at the fame time, from the oppofite fide, the fixth glafs, that reprefents the Trojan troops; obferving to move them flowly both in advancing and retreating, to imitate a combat *. Then

* He that moves the glaffes, feeing the effect they produce, is the better able to render the reprefentation as natural as poffible.

draw

draw up, by degrees, the ſixth, on which are painted the fire, flame, and ſmoke, ſo that the palaces and houſes painted on the firſt glaſs, may appear to take fire gradually, and at laſt preſent a general conflagration. After having repreſented theſe incidents with the greateſt attention, you let fall the curtain to prepare for the third act.

In the third act may be repreſented the inſide of Priam's palace, where is ſeen an altar, round which ſeveral Trojan princeſſes appear, who have fled thither for ſafety.

On the firſt glaſs may be painted the palace.

On the ſecond, a view of the back part of the palace, with the altar.

On the third, Priam with ſeveral Trojan men and women.

On the fourth, Pyrrhus, and a troop of Greeks.

On the fifth, the ſame actors, with the palace in flames.

On

On the ſixth, A conflagration.

The two firſt glaſſes which are to be drawn up, ſhould be placed before you raiſe the curtain. Then paſs the third; next advance the fourth, which being drawn up, diſcovers on the fifth the palace in flames, then drawing up the ſixth, let down the firſt, that the palace may appear entirely deſtroyed by the conflagration.

The fourth act may repreſent the environs of Troy, with a diſtant proſpect of the ſea. The firſt and third glaſſes of the firſt act may be here uſed, to which may be added a third, repreſenting Eneas bearing his father Anchiſes, followed by his ſon Iulus, and ſome Trojans. With this glaſs may be repreſented the flight of the Trojans, and the embarkment of Eneas, with another glaſs, on which are painted certain veſſels.

To this act the following ſcenes may be added. The cave of Æolus; the back part

part of the cave; Æolus; the winds; Juno in her chariot.

The fifth act ſhould repreſent the open ſea, with the fleet of Eneas ſailing for Italy.

On the firſt glaſs muſt be painted the ſea, as in the tenth Recreation, or elſe the waves ſhould be imitated by another glaſs under the firſt.

On the ſecond, The Trojan fleet.

On the third, Neptune in his car.

On the fourth, the palace of Jupiter.

On the fifth, the inſide of the palace; the Gods aſſembled in council, with Venus, obtaining leave of Jupiter for Eneas to land in Italy.

After having placed the firſt glaſs, that repreſents a calm ſea, the curtain is raiſed, and the ſecond ſcene is advanced, which contains the Trojan fleet. The firſt is then brought forward, to repreſent a violent

lent tempeſt: then raiſing the third glaſs, Neptune appears, who commands the waves to be ſtill, which is done by making the tempeſt ſubſide by degrees. The fleet then advances, and paſſes over the whole theatre: preſently after the fourth and fifth ſcenes deſcend, that repreſent Olympus, and finiſh the exhibition.

Note. We muſt here repeat, that if you would repreſent a ſubject of this ſort to advantage, it is quite neceſſary that the glaſſes be well painted: and thoſe that are to be in front, ſhould be in ſtronger and more opaque colours, that the images of thoſe behind may not appear mixed with them, which will be the caſe if they are all equally tranſparent.

The glaſſes ſhould alſo be of different lengths, that ſome being placed before the others are drawn away, their extremities may not be perceived.

The larger theſe ſubjects are repreſented the better effect they will have: the front of the theatre ſhould appear to be about three feet wide: and, as we have ſaid elſewhere, if ſome parts of the figures were moveable it would ſtill add to the variety of the entertainment.

This and moſt of the other Recreations we have here given in the two firſt parts of Optics, appear to have been invented by M. Guyot, who has taken no ſmall pains in the improvement of this ſort of recreations.

CATOP-

CATOPTRICS.

CATOPTRICS is that part of optics which explains the properties of reflected light, and particularly that which is reflected from mirrors.

DEFINITIONS.

1. Every polished body that reflects the rays of light is called a mirror, whether its surface be plane, spherical, conical, cylindric, or of any other form whatever.

2. Of mirrors there are three principally used in optical experiments, which are, the plane mirror, GHI, (Plate V. Fig. 1.) the spherical convex mirror, GHI, (Plate V. Fig. 2.) and the spherical concave mirror, GHI, (Plate V. Fig. 3.)

3. The point K, (Plate V. Fig. 2 and 3.) round which the reflecting surface of a spherical mirror is described, is called its centre. The line KH, drawn from its

center

center perpendicular to its two ſurfaces, is the axis of the mirror, and the point H, to which that line is drawn, is its vertex.

4. The diſtance between the lines A G and B G, (Plate V. Fig. 1.) is called the angle of incidence, and the diſtance between B G and C G is the angle of reflection.

APHORISMS.

I. In a plane Mirror.

1. The image D F. (Plate V. Fi. 1.) will appear as far behind the mirror, as the object A C is before it.

2. The image will appear of the ſame ſize, and in the ſame poſition as the object.

3. Every ſuch mirror will reflect the image of an object of twice its own length and breadth.

4. If the object be an opaque body, and its rays fall on the mirror nearly in direct lines, there will be only one image viſible, which

which will be reflected by the inner ſurface of the glaſs. But

5. If the object be a luminous body, and its rays fall very obliquely on the mirror, there will appear to an eye placed in a proper poſition, ſeveral images; the firſt of which, reflected from the outer ſurface of the glaſs, will not be ſo bright as the ſecond, reflected from the inner ſurface. The following images, that are produced by repeated reflections of the rays between the two ſurfaces of the glaſs, will be in proportion leſs vivid, to the eighth or tenth, which will be ſcarce viſible.

II. In a Spherical Convex Mirror.

1. The image DF, (Plate V. Fig. 2.) will always appear behind it.

2. The image will be in the ſame poſition as the object.

3. It will be leſs than the object.

4. It will be curved, but not, as the mirror, ſpherical.

5. Parallel rays falling on this mirror will have the focus or image at half the diſtance

diſtance of the center K, from the mirror.

6. In converging rays, the diſtance of the object muſt be equal to half the diſtance of the center, to make the image appear behind the mirror.

7. Diverging rays will have their image at leſs than half the diſtance of the center. If the object be placed in the center of the mirror, its image will appear at one-eighth of that diſtance behind it.

III. In a Spherical Concave Mirror.

1. That point where the image appears of the ſame dimenſions as the object, is the center of that mirror.

2. Parallel rays will have their focus at one half the diſtance of the center.

3. Converging rays will form an image before the mirror.

4. In diverging rays, if the object be at leſs than one half the diſtance of the center, the image will be behind the mirror, erect, curved, and magnified, as DEF (Plate V. Fig. 3.) but if the diſtance of the object be greater, the image will be before

the mirror, inverted and diminifhed, as DEF, (Plate V. Fig. 4.)

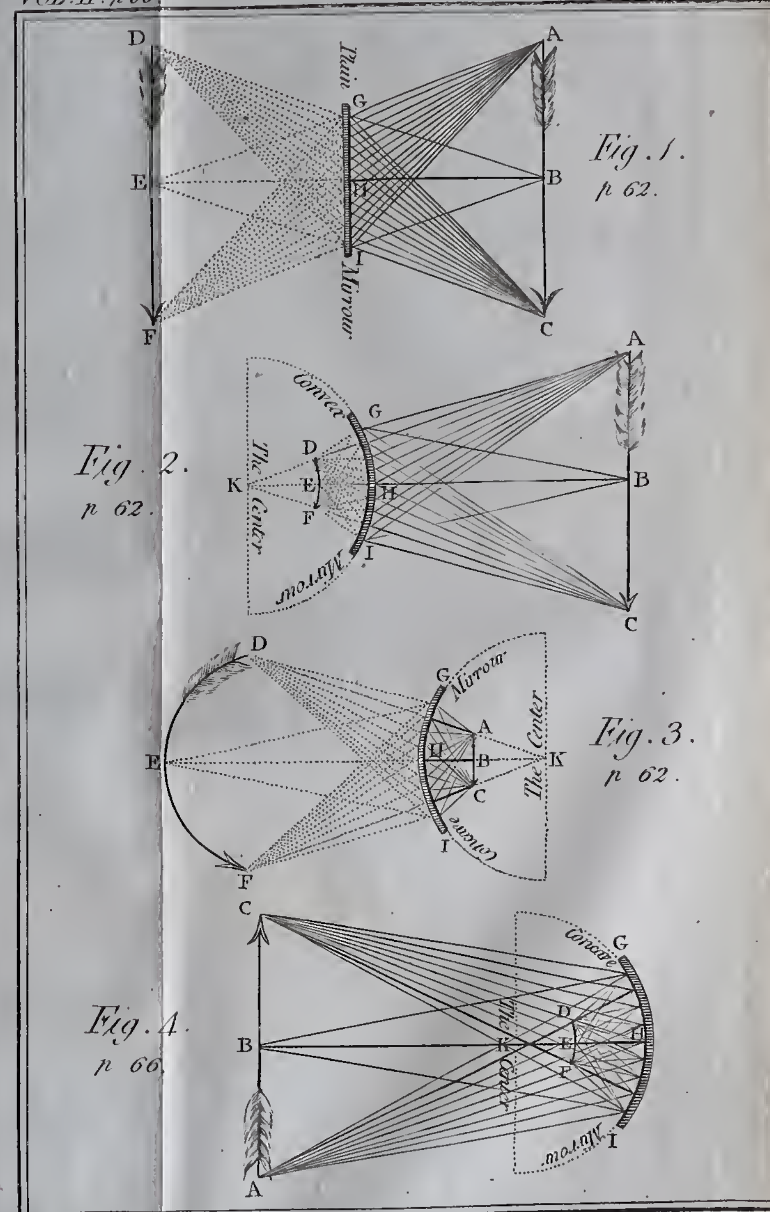
5. The fun's rays falling on a concave mirror, and being parallel, will be collected in a focus at half the diftance of its center, where their heat will be augmented in proportion of the furface of the mirror to that of the focal fpot.

6. If a luminous body be placed in the focus of a concave mirror, its rays being reflected in parallel lines, will ftrongly enlighten a fpace of the fame dimenfion with the mirror, at a great diftance. If the luminous object be placed nearer than the focus, its rays will diverge, and confequently enlighten a larger fpace*.

IV. In all plane and fpherical mirrors the angle of incidence is equal to the angle of reflection†.

* It is on this principle that reverberators are conftructed.

† This aphorifm holds true of cylindric mirrors alfo, and of thofe whofe furfaces are eliptical, parabolic, &c.



J. Lodge Sculp.

RECREATION XIV.

The boundleſs gallery.

CONSTRUCT a box AB, Plate VI. Fig. 1. of about a foot long, eight inches wide, and ſix high; or what other dimenſion you ſhall think fit, provided it does not greatly vary from theſe proportions.

On the inſide of this box, and againſt each of its oppoſite ends A and B, place a mirror of the ſame ſize. Take off the quickſilver from the mirror that you place at B, for about an inch and an half, at the part C, where you are to make a hole in the box of the ſame ſize, by which you may eaſily view its inſide. Cover the top of the box with a frame, in which muſt be placed a tranſparent glaſs, covered with gauze, on the ſide next the inner part of the box. Let there be two grooves at the parts E and F to receive the two painted ſcenes hereafter mentioned. On two pieces

of cut pafteboard let there be fkilfully painted on both fides (fee Fig. 2. and 3.) any fubject you think proper; as woods, gardens, bowers, colonades, &c. and on two other pafteboards, the fame fubjects on one fide only; obferving that there ought to be in one of them fome object relative to the fubject placed at A, that the mirror placed on D may not reflect the hole at C on the oppofite fide.

Place the two boards painted on both fides (Fig. 2. and 3.) in the grooves E and F; and thofe that are painted on one fide only, againft the oppofite mirrors C and D; and then cover the box with its tranfparent top. This box fhould be placed in a ftrong light to have a good effect.

When the eye is placed at C, and views the objects on the infide of the box, of which fome, as we have faid, are painted on both fides, they are fucceffively reflected from one mirror to the other; and if, for

for example, the painting confifts of trees, they will appear like a very long vifta, of which the eye cannot difcern the end: for each of the mirrors repeating the objects, continually more faintly, contribute greatly to augment the illufion.

RECREATION XV.

The four magical mirrors.

TAKE a fquare box ABCD, (Plate VI. Fig. 4.) of about fix inches long, and twelve high*; cover the infide of it with four plane mirrors, which muft be placed perpendicular to the bottom of the box CHFD.

Place certain objects in relief on the bottom of this box; fuppofe, for example, a piece of fortification, (as Fig. 5.) with tents, foldiers, &c. or any other fubject

* We do not mean to limit the box to this fize; any other may be ufed, provided, however, that it have nearly the fame proportions.

that you judge will produce an agreeable effect by its difpofition, when repeatedly reflected by the mirrors.

On the top of this box place a frame of glafs, in form of the bottom part of a pyramid, whofe bafe AGEB, is equal to the fize of the box: its top ILMN, muft form a fquare of fix inches, and fhould not be more than four or five inches higher than the box. Cover the four fides of this frame with a gauze, that the infide may not be vifible but at the top ILMN, which fhould be covered with a tranfparent glafs.

When you look into this box through the glafs ILMN, the mirrors that are diametrically oppofite each other, mutually reflecting the figures enclofed, the eye beholds a boundlefs extent, completely covered with thefe objects; and if they are properly difpofed, as in the example here given, in Fig. 5. the illufion will occafion

Fig. 1. p 67.

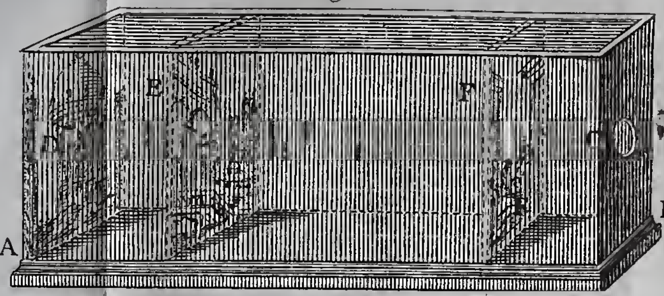


Fig. 2. p 68.

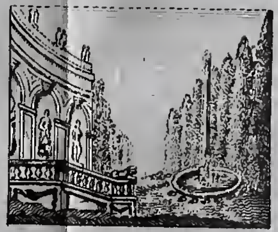


Fig. 3. p 68.

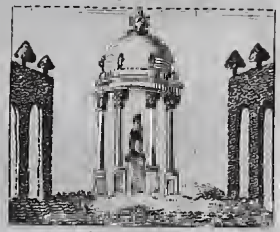


Fig. 5. p 70.

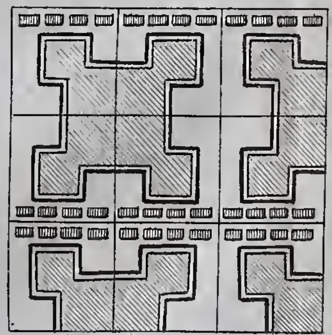
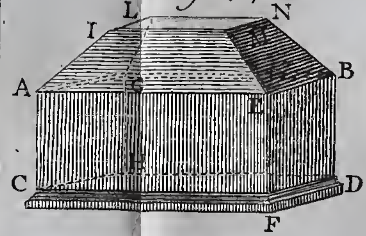


Fig. 4. p 69.



J. Lodge Sculp.

occaſion no ſmall ſurprize, and afford great entertainment.

Note, The nearer the opening ILMN is to the top of the box, the greater will be the apparent extent of the ſubject. The ſame will happen if the four mirrors placed on the ſides of the box be more elevated. The objects, by either of theſe diſpoſitions, will appear to be repeated nine, twenty-five, forty-nine times, &c. by taking always the ſquare of the odd numbers of the arithmetic progreſſion 3, 5, 7, 9, &c. as is very eaſy to conceive, if we remember that the ſubject encloſed in the box is always in the center of a ſquare, compoſed of ſeveral others, equal to that which forms the bottom of the box.

Other pieces of the ſame kind (that is viewed from above) may be contrived, in which mirrors may be placed perpendicular on a triangular, pentagon, or

 hexagon,

hexagon (that is, a three, five, or ſix-ſided) plane. All theſe different diſpoſitions, properly directed, as well with regard to the choice as poſition of the objects, will conſtantly produce very remarkable and pleaſing illuſions.

If inſtead of placing the mirrors perpendicular, they were to incline equally, ſo as to form part of a reverſed pyramid, the ſubject placed in the box would then have the appearance of a very extenſive globular or many-ſided figure.

RECREATION XVI.

The enchanted palace.

ON the hexagonal or ſix-ſided plane ABCDEF (Pl. VII. Fig. 1.) draw ſix ſemi-diameters GA, GB, GC, GD, GE, GF, and on each of theſe place, perpendicularly, two plane mirrors, which muſt join

join exactly at the center G*. Decorate the exterior boundary of this piece (which is at the extremity of the angles of the hexagon) with ſix columns, that at the ſame time ſerve to ſupport the mirrors, by grooves formed on their inner ſides. (See the profile, Fig. 1.) Add to theſe columns their entablatures, and cover the edifice in ſuch manner as you ſhall think proper.

In each one of theſe ſix triangular ſpaces, contained between two mirrors, place little figures of paſteboard, in relief, repreſenting ſuch objects as when ſeen in an hexagonal form will produce an agreeable effect. To theſe add ſmall figures of enamel; and take particular care to conceal, by ſome object that has relation to the ſubject, the place where the mirrors join, which, as we have ſaid before, all meet in the common center G.

* Theſe mirrors, placed back to back, muſt be as thin as poſſible.

When

When you look into any one of the six openings of this magical palace, the objects there contained being repeated six times, will seem entirely to fill up the whole of the building. This illusion will appear very remarkable; especially if the objects made choice of are properly adapted to the effect that is to be produced by the mirrors.

Note, if you place between two of these mirrors part of a fortification, as a curtain and two demi-bastions, you will see an entire citadel, with its six bastions. Or if you place part of a ball room, ornamented with chandeliers and figures in enamel, all those objects being here multiplied will afford a very pleasing prospect.

RECREATION XVII.

To draw an irregular figure, which ſhall appear regular when viewed in a plane mirror

DIVIDE the ſquare ABCD (Pl. VII. Fig. 2.) into ſuch number of leſſer ſquares as you ſhall think proper, and then draw on it the ſubject you would repreſent. Make the line G F (Fig. 3.) equal to a ſide of the ſquare ABCD; and after having divided it into two equal parts at the point E, through that point draw the indefinite line AB, which muſt cut the line G F at right angles. Take any two points in the line A B, as A and B, equally diſtant from the point E, and draw from the point A the lines A C and A D, which you muſt continue till they meet the line CD, parallel to G F.

On the point A draw A H perpendicular to A B, and of an equal length with the line

line CD, that is double of that which forms a ſide of the ſquare A B C D.

Divide the line C D into as many equal parts as there are in a ſide of the ſquare ABC D, and from the point A draw the lines A*a*, A*b*. From the point of view H, draw the line H D, which by cutting the lines A *a*, A B, A *b*, will ſhow you the points of the ſection from which you are to draw the lines *f g*, parallel to G F and C D.

Then tranſpoſe on the trapezium, or irregular four-ſided figure, GFCD (which will be divided into as many perſpective ſquares as there are natural ſquares in Fig. 1. A B C D) the deſign traced on that ſquare ; and on the line F G, place perpendicularly a mirror of an equal ſize with that ſquare. The diſtorted figure traced on the trapezium GCFD being then viewed in the mirror from a point elevated perpendicularly over the point B, to the height of

of CD, will appear exactly ſimilar to that traced on the ſquare A B C D. It will appear equally regular if the mirror be taken away, and it be viewed from the point H.

Note, Before you colour the diſtorted figure drawn on the trapezium, you ſhould paſte it on a board of a parallelogram figure, whoſe ſides are equal to the lines EB and CD : and fill up the ſpace beyond the trapezium with ſuch figures as you ſhall think proper, the better to diſguiſe it : theſe extra figures will not appear in the mirror, if you have the precaution to raiſe at the point B a ſtand that ſhall bear a circle with a ſmall hole, thro' which the object is to be ſeen in the mirror. This contrivance will conſiderably augment the illuſion.

RECREATION XVIII.

The magical dial.

PROCURE a dial-caſe as ABCD (Pl. VII. Fig. 4.) of the ſize of thoſe that are commonly uſed to hold a watch. Let it be placed on a pedeſtal CDEF, in which there muſt be a ſmall drawer H, that can hold the plate ABCD, (Fig. 5.) on which plate draw the circle of hours E, and in the center let there be a magnetic needle, placed on the point of an axis, which, paſſing through the plate, carries on its other point an artificial magnet, that muſt be concealed in the part under the plate*.

Place at the bottom of the dial caſe, at the part I, another dial, the hours of

* The magnetic needle itſelf may do, if it be not too far from the other dial. That this needle may not be ſuſpected of having been touched it may be gilt, ſo as to appear like braſs.

which

which are to be reverſed, as it is expreſſed in Fig. 6. and whoſe hour of twelve muſt be placed next the front of the caſe G. Adjuſt a pivot to the center of this plate, and fix on it a magnetic needle.

Cover the openings at the ſides of the front of the dial-caſe (except where the dial appears) with a glaſs lined with gauze on the inſide, that the light may paſs in and illumine the dial that is there placed. Towards the top of the dial-caſe place an inclined mirror L M, which by reflecting the dial placed at the bottom of the caſe, will make it viſible at the part N, where you muſt adjuſt a circle of paſteboard, that bordering the part where the dial appears, and being placed on the inſide, will prevent the borders or the back part of the mirror from being ſeen.

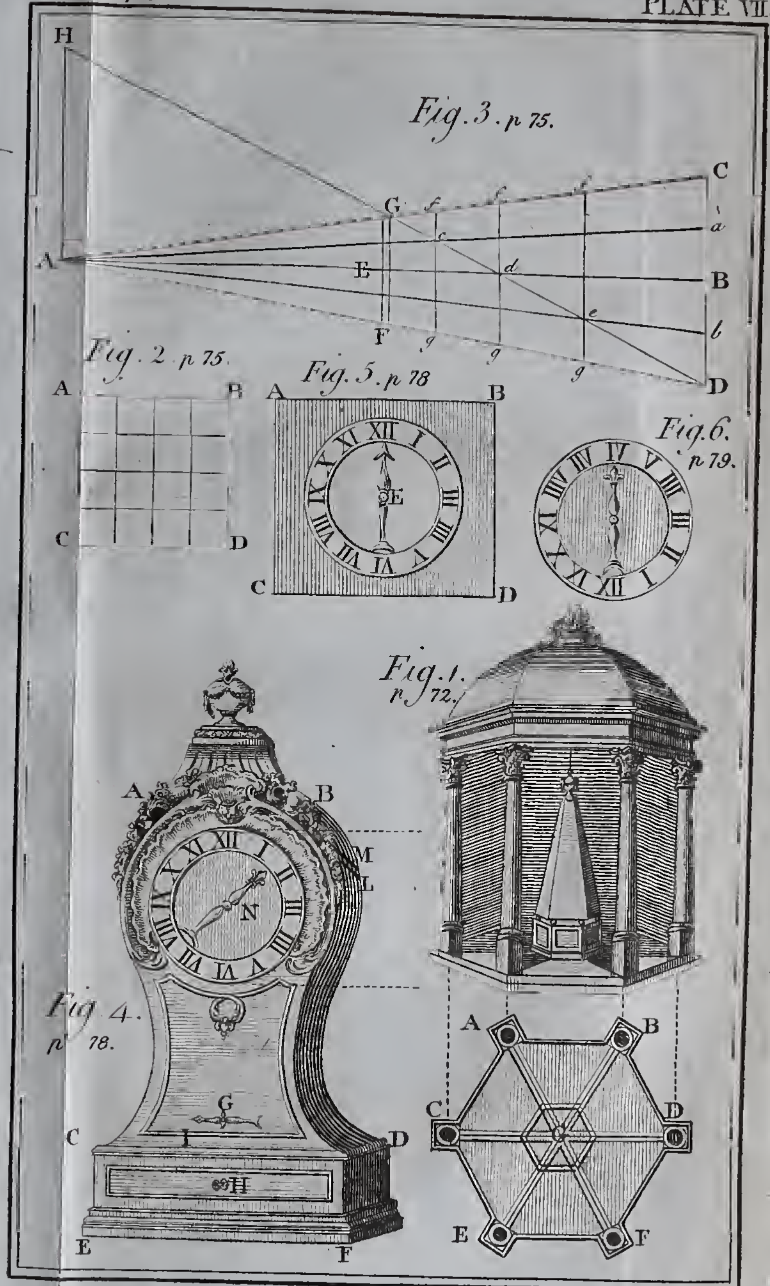
Matters being thus adjuſted, when the hand of the dial (Fig. 5.) is ſet to any hour, and it is placed in the drawer, ſo that the hour

hour of twelve may be next the ring by which it is pulled out, the hand of the other dial, placed at the bottom of the caſe, will direct itſelf to the ſame hour, and by looking at the part N, you will ſee by the reflection of the mirror, the hour appear in the front of the dial plate.

Give the dial (Fig. 5.) to any one, and tell him to ſet the hand privately to any hour he pleaſe, and then place it in the drawer, only obſerving that the hour of twelve be next the ring, and he will then ſee that the hand of the dial at top will direct itſelf to the ſame hour.

Note, If attention be had to place the dial-caſe ſo on the table, that the hand of the dial which is concealed (and which will of itſelf turn towards the north, when the other dial is not under it) direct itſelf to the preſent hour when the experiment is making, it will appear the more extraor-

dinary;



J. Lodge sculp.

dinary; becaufe, when the drawer is taken away, it will again turn to the prefent hour, which will render the caufe of the illufion ftill more myfterious.

RECREATION XIX.

The box of divination.

LET a box be made with hinges, like ABCD (Pl. VIII. Fig. 1.) of about eight inches long, two wide, and half an inch thick; divide the infide of it into four equal parts, by fmall partitions. Have four fmall cafes E, F, G, H, which will each of them fit any of the divifions, and in each of them you muft fix a fmall artificial magnet, whofe poles are to be placed as is expreffed in the figure. Cover thefe cafes with pafteboard or very thin ivory, on which you are to write any four figures you fhall think fit.

To a table IL, whofe wood is not too thick, fit a drawer, at the bottom of which

muſt be placed an inclined mirror MN, of the ſame length and breadth with the box juſt mentioned. Under the board that forms the top of the table, and toward the ſide where the drawer opens, place a ſmall braſs rod, turned up at its extremities, and on which there muſt be four pivots, at the ſame diſtance from each other as are the centers of the caſes placed in the box. Theſe pivots are to ſupport four circles of paſteboard PQRS (Fig. 2, and 3.) which muſt each of them have a magnetic needle.

Obſerve, that the figures on the paſteboard muſt not only be reverſed, but muſt be wrote on the under ſide, next the bottom of the drawers, that when it is opened they may be ſeen in the mirror there placed. Have regard alſo to the diſpoſition of the poles of the needles, in the manner as is clearly expreſſed in the third figure.

Matters

Matters being thus prepared, when you have placed on the table the box and the four numbers there included, ſo that they may be exactly over the four circles of paſteboard concealed in the drawer, that is, that the centers of the one may be preciſely over the centers of the other, the needles on the circles will conform themſelves exactly to the magnets in the caſes; ſo that if an inſtant after having placed the box, you open the drawer ſo far as to ſee the mirror, you will there perceive the number that the four figures on the caſes make.

Then give the box and the four caſes to any one, and tell him to form privately any number, by placing the caſes in what order he ſhall think fit, and return you the box firmly cloſed. You then place it on the table over the circles, and opening the drawer, under pretence of taking out an opera-glaſs, you caſt your eye on the mirror, and obſerve the order of the figures

there expreſſed. You then ſhut the drawer, and retiring to a diſtance, pretend to diſcern, by the opera-glaſs, the number you have obſerved.

RECREATION XX.

The magical perſpectives.

AT the bottom of an heptagonal or ſeven-ſided box, as A B C D E F G (Pl. VIII. Fig. 4.) of about eight inches diameter and an inch and an half deep*. Place a circle of paſteboard, of five inches and a half diameter, very light and moveable, on a pivot fixed in the center H: on this circle fix a ſtrongly magnetic needle I, and divide the circle into 21 equal parts, as is expreſſed in Fig. 7. The top of the box is to be covered with glaſs, over which you muſt paſte a ſheet of very fine paper, painted the ſame colour with the box, and

* This box ſhould be ſo conſtructed as to appear to be the pedeſtal to the three perſpectives hereafter deſcribed.

var-

varniſhed, that the light may eaſily paſs through it, and illumine the objects which are to be wrote or painted on the paſte-board circle. On the middle of the top of this box erect a column I (ſee Fig. 5.) ſupported on a pedeſtal M, and crowned with its capital N.

In the glaſs that covers the box there muſt be three circular holes, at equal diſtances from each other, as O, P, Q, each of them three fourths of an inch in diameter; and on each muſt be fixed, immoveable, a perſpective glaſs, like that in the ſixth figure of this plate.

Conſtruction of the perſpective glaſs.

Provide a ſtand of wood A (Fig. 6.) in which a hole is made from top to bottom, of 3-4ths of an inch in diameter; on this ſtand place the perſpective B C, which muſt have a ſecond tube D, like the common glaſſes. In the larger part of it F,

there muſt be a ſmaller oval mirror E, which inclines or is elevated as the tube D is thruſt in or drawn out. Let there be a circular hole at that part of the tube which reſts on the ſtand A, that when the mirror is inclined, you may ſee through the ſtand of the perſpective any object that ſhall be placed in the box, under one of the holes OPQ*. Let the three perſpectives ſo conſtructed be placed, immoveable, over thoſe three holes.

The combination of objects that may be drawn on the moveable circle in the box.

This circle is to be divided, as we have ſaid, into 21 equal parts, and each of theſe diviſions muſt appear under each of the openings O, P, Q, as the circle turns round on its pivot.

* At the bottom of the ſtand of each perſpective there may be placed a lens of five or ſix inches in diameter, to magnify the object.

You

You are to determine what three objects you would have appear under the three perspectives; and supposing, for example, that they are represented by the numeral figures 1, 2, and 3, you will find that these three figures will admit of six combinations or different dispositions, as

1,2,3. 1,3,2. 2,1,3. 2,3,1. 3,1,2. 3,2,1*.

Then place the numbers, or the objects they represent, in such order that the first number, 1, of the first combination, 1,2,3, may be in the first division A, of the circle, (see Fig. 7.) the second number, 2, in the eighth, and the third number, 3, in the fifteenth division: that the first number, 1, of the second combination, may be placed in the second division B; the second number, 3, in the ninth division; and the third number, 2, in the sixteenth division, &c. Having thus filled up eighteen of the divisions with the six combinations of numbers, the other three are to be left blank.

* See vol. I. page 9. aphorism 16.

The circle being thus prepared, is to be placed on its pivot, and to one of the feven fides of the box (Fig. 4.) is to be adjufted a lever or ftop, that being let down on the circle, at pleafure, may prevent it from turning.

When the three perfpectives are placed on the box, and turned toward the column erected on its center, if the fmalleft tube be thruft in, it raifes the mirror that is contained in each of them, and, by the hole B the column is feen. If on the contrary the fmall tube be drawn a little way out, the mirror becomes inclined, and you then fee one of the three objects that are placed in the box, under each opening in the ftands of the perfpective, and thefe objects will neceffarily appear in the order of one of the fix combinations of which they are alone fufceptible.

By placing the box on the table, in which a magnetic bar, fix inches long,

long*, muſt be concealed, and whoſe direction you know, you may eaſily make the three objects above mentioned appear oppoſite the three holes O, P, Q, with all their changes; for nothing more is neceſſary than to place the box according to a mark that is on the table, oppoſite to which you are to place one of its ſeven ſides; and by letting down the private check you keep the circle fixed.

The amuſements that are to be made with theſe perſpectives may be varied according to the number of different objects that can be placed on the moveable circle. We ſhall content ourſelves here with giving an example in numbers, which may be applied to any other ſubject, the difference of objects making not the leaſt difference in the manner of performing this Recreation; which, when well executed,

* This bar ſhould be ſtrongly impregnated, that it may readily turn the paſteboard circle.

never

never fails to excite the higheſt admiration.

Firſt then, you are ſo to place the moveable circle, that the three diviſions on which there is nothing wrote may appear under the three holes O, P, Q*, and the ſmall tube of the perſpectives is to be ſo diſpoſed that the mirrors on the inſide may incline to forty-five degrees †, and reflect the objects placed under thoſe holes. The perſpectives being thus diſpoſed, they are placed on the table, and liberty is given thoſe that deſire it, to look into them, as they can then ſee no object. You are then to preſent to three different perſons, three ſuch objects as you ſhall think proper ‡;

* This muſt be done privately, by means of the check, before the machine is brought to the table.

† That is, be half way between a line drawn perpendicular to the ground, and its ſurface.

‡ Theſe objects may be either numbers, flowers, cards, mottos, &c. it is only neceſſary that the circle be properly painted. You may alſo have different circles to vary the Recreation yet farther, by privately changing them.

we

we will ſuppoſe here the three numbers 1, 2, 3. When each of the three perſons has made choice of one of theſe numbers, you roll the three cards on which they are wrote, altogether, and put them into the column, oppoſite to which the three perſpectives are placed; and give each perſon liberty to chooſe in which glaſs he will ſee his object*.

When the three parties have choſe their perſpectives, the box is to be placed on the table, where the bar is concealed, taking due care to ſet it in ſuch direction that the openings O, P, Q, may correſpond to thoſe parts of the circle on which the objects are wrote. A ſhort time muſt be given the circle to ſettle, and then the

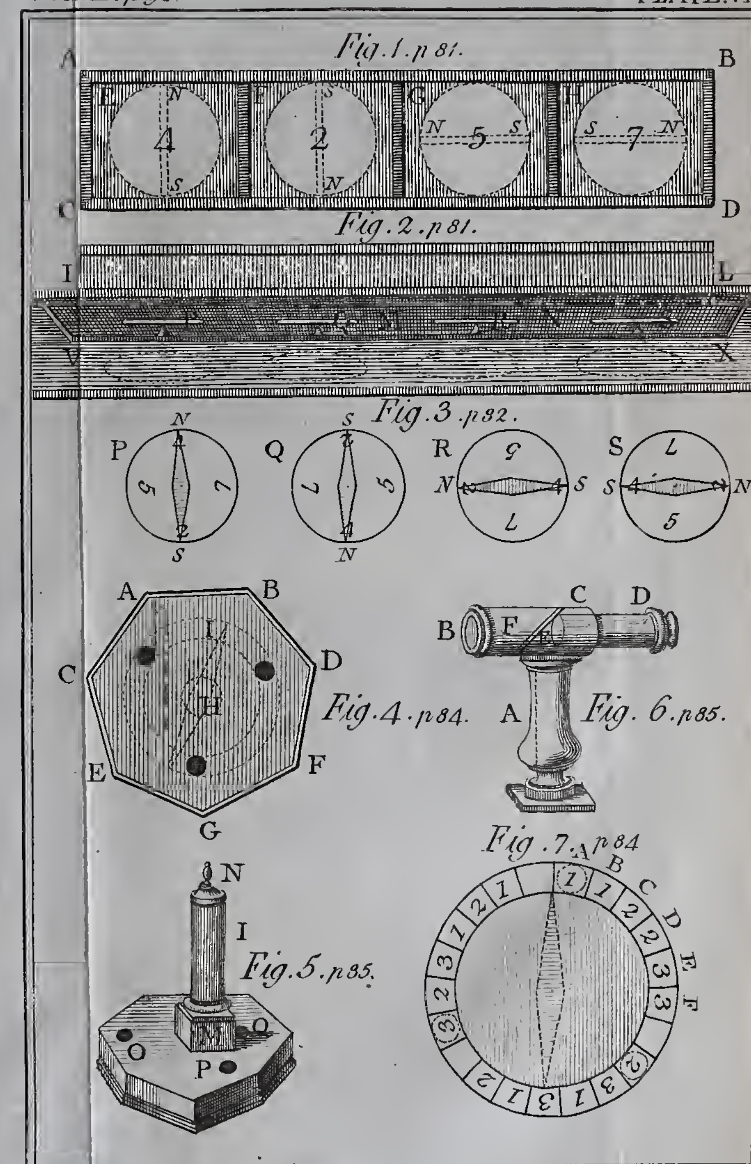
* It is immaterial which glaſs the firſt perſon chooſes, before the box is placed on the table, but if the ſecond ſhould not name that under which his object is placed, the box muſt be moved; however it is an equal chance but he does, and in that caſe they may all three ſee their objects at the ſame time.

check

check muſt be privately let down. The three perſons then looking through the perſpective they have each of them choſe, their objects will naturally appear to them in that part of the column where their cards were placed *.

Note, It requires ſome memory to perform this recreation with facility, as you muſt keep in mind the ſix changes of order, which the liberty you give the ſpectators to ſee through which of the glaſſes they pleaſe, requires. You may, however, to avoid charging your memory, trace on the box certain ſigns, which at the ſame time that they appear to be ornaments, may ſhow you in what direction the box is to be placed.

* You may then propoſe to each of them to make him ſee his object through another perſpective, which you do by removing the check, and putting the box in a different direction.



J. Lodge Sculp.

RECREATION XXI.

The penetrating perſpective.

WITHIN the caſe ABCD, (Plate X. Fig. 1.) place four mirrors, O, P, Q, R, ſo diſpoſed that they may each of them make an angle of forty-five degrees, that is, that they may be half way inclined from the perpendicular, as in the figure. In each of the two extremities A B, make a circular overture, in one of which fix the tube G L, in the other the tube M F, and obſerve that in each of theſe is to be inſerted another tube, as H and I*.

Furniſh the firſt of theſe tubes with an object glaſs at G, and a concave eye-glaſs at F. You are to obſerve that, in regulating the focus of theſe glaſſes with regard to the length of the tube, you are to ſup-

* Theſe four tubes muſt terminate in the ſubſtance of the caſe, and not enter the inſide, that they may not hinder the effect of the mirrors.

pofe it equal to the line G, or vifual pointed ray, which entering at the overture G, is reflected by the four mirrors, and goes out at the other overture F, where the occular glafs is placed. Put any glafs you will into the two ends of the moveable tubes H and I; and laftly place the machine on a ftand E, moveable at the point S, that it may be elevated or depreffed at pleafure.

When the eye is placed at F, and you look through the tube, the rays of light that proceed from the object T, paffing through the glafs G, are fucceffively reflected by the mirrors O, P, R, and Q, to the eye at F, and there paint the object T, in its proper fituation, and thefe rays appear to proceed directly from that object.

The two moveable tubes H and I, at the extremities of each of which a glafs is placed, ferve only the more to difguife the illufion

illusion, for they have no communication with the interior part of the machine. This instrument being moveable on the stand E, may be directed to any object; and if furnished with proper glasses will answer the purpose of a common perspective.

The two moveable tubes H and I being brought together, the machine is directed toward any object, and desiring a person to look in at the end F, you ask him if he see distinctly that object. You then separate the two moveable tubes, and leaving a space between them sufficient to place your hand, or any other solid body, you tell him that the machine has the power of making objects visible thro' the most opaque body; and as a proof you desire him then to look at the same object, when to his great surprize, he will see it as distinct as when there was no solid body placed between the tubes.

Note, This recreation is the more extraordinary, as it is very difficult to conceive how the effect is produced. The two arms of the case appearing to be made to support the perspective glass: and to whatever object it is directed, the effect is still the same.

RECREATION XXII.

The magician's mirrors.

IN the wainscot of a room make two overtures, of a foot high, and ten inches wide, and about a foot distant from each other. Let them be at the common height of a man's head; and in each of them place a transparent glass, surrounded with a frame, like a common mirror.

Behind this partition place two mirrors, one on the outward side of each overture, inclined to the wainscot in an angle of forty-five degrees*; let them be both eighteen inches square: let all the space be-

* See page 90.

tween,

tween them be enclofed by boards or pafteboard, painted black, and well clofed, that no light may enter; let there be alfo two curtains to cover them, which may be drawn afide at pleafure.

When a perfon looks into one of thefe fuppofed mirrors, inftead of feeing his own face he will percive the object that is in the front of the other; fo that if two perfons prefent themfelves at the fame time before thefe mirrors, inftead of each one feeing himfelf, they will reciprocally fee each other.

Note, There fhould be a fconce with a candle placed on each fide of the two glaffes in the wainfcot, to enlighten the faces of the perfons who look in them, otherwife this experiment will have no remarkable effect.

This Recreation may be confiderably improved by placing the two glaffes in the

 wainfcot,

wainſcot, in adjoining rooms, and a number of perſons being previouſly placed in one room, when a ſtranger enters the other, you may tell him his face is dirty, and deſire him to look in the glaſs, which he will naturally do; and on ſeeing a ſtrange face he will draw back: but returning to it, and ſeeing another, another, and another, like the phantom kings in Macbeth, what his ſurpriſe will be is more eaſy to conceive than expreſs. After this, a real mirror may be privately let down on the back of the glaſs, and if he can be prevailed to look in it once more, he will then, to his farther aſtoniſhment, ſee his own face; and may be told, perhaps perſuaded that all he thought he ſaw before was mere imagination.

How many tricks leſs artful than this, have paſſed in former times for ſorcery; and paſs at this time, in ſome countries, for apparitions:

Note, When a man looks in a mirror that is placed perpendicular to another, his face

face will appear entirely deformed. If the mirror be a little inclined, ſo as to make an angle of eighty degrees (that is one ninth part from the perpendicular) he will then ſee all the parts of his face except the noſe and forehead. If it be inclined to ſixty degrees (that is, one third part) he will appear with three noſes and ſix eyes: in ſhort, the apparent deformity will vary at each degree of inclination; and when the glaſs comes to forty-five degrees, (that is, half way down) the face will vaniſh. If inſtead of placing the two mirrors in this ſituation, they are ſo diſpoſed that their junction may be vertical, their different inclinations will produce other effects; as the ſituation of the object relative to theſe mirrors is quite different. The effects of theſe mirrors, though remarkable enough, occaſions but little ſurprize, as there is no method of concealing the cauſe by which they are produced.

RECREATION XXIII.

Polemoſcopes.

BY the term polemoſcope is meant any inſtrument, whether catoptric or dioptric, by which you may ſee what paſſes in another place, without being ſeen from thence. The machines contain one or more plane mirrors, which convey by reflection the image of the object to the eye of the ſpectator. There are ſmall inſtruments of this kind, made in the form of an opera-glaſs, by which, while you ſeem to look ſtrait forward, you ſee what paſſes on one ſide, and by that means gratify your curioſity without the appearance of incivility.

To the conſtructing of this ſort of polemoſcope nothing more is neceſſary than to fix in a common opera-glaſs a ſmall mirror inclined to an angle of forty-five degrees, and adjuſt a proper object-glaſs. This glaſs at the ſame time may anſwer its

its common uſe, by adding an object-glaſs, and ſo contriving the ſmall tube that it may remove the mirror at pleaſure, as in the 21ſt Recreation.

The tube of a polemoſcope may be placed againſt a wall, the inclined mirror being a little above it, and turned outwards, by which means you will diſcover what paſſes on the other ſide, without being ſeen yourſelf. An inſtrument of this ſort would be of uſe in ſieges, where there is danger without the wall from the fire of the enemy; and on other occaſions. This inſtrument may be alſo ſo conſtructed, that the tube may turn round, and the mirror be elevated or depreſſed, that you may ſee ſucceſſively and at pleaſure, all the objects that you would perceive if you were at the top of the wall againſt which the inſtrument is placed.

RECREATION XXIV.

The enchanted mirrors.

MAKE a box of wood, of a cubical figure, ACBD, (Plate X. Fig. 2.) of about fifteen inches every way. Let it be fixed on the pedeſtal P, at the uſual height of a man's head. In eace ſide of this box let there be an opening of an oval form, of ten inches high, and ſeven wide.

In this box place two mirrors A, D, with their backs againſt each other; let them croſs the box in a diagonal line, and in a vertical poſition. Decorate the openings in the ſides of this box with four oval frames and tranſparent glaſſes, and cover each of them with a curtain, ſo contrived that they may all draw up together.

Place four perſons in front of the four ſides, and at equal diſtances from the box, and then draw up the curtains that they

they may ſee themſelves in the mirrors; when each of them, inſtead of his own figure, will ſee that of the perſon who is next him, and who, at the ſame time, will ſeem to him to be placed on the oppoſite ſide. Their confuſion will be the greater, as it will be very difficult for them to diſcover the mirrors concealed in the box. The reaſon of this phenomenon is evident, for though the rays of light may be turned aſide by a mirror, yet, as we have before ſaid, they always appear to proceed in right lines.

RECREATION XXV.

The animated optic balls.

(By a ſingle reflection.)

THIS piece of catoptrics, as well as that which follows of double reflection, being of the claſs that produces the moſt pleaſing illuſion, we ſhall here give a full detail of the manner in which it is to be executed.

Provide a wooden box ABCD, of about two feet high, and fifteen inches wide (Plate IX. Fig. 1.) and toward the top let there be made an opening E, of eight or nine inches high, and ſeven or eight inches wide, and in this opening fix a tranſparent glaſs*. Let the box be two feet deep (ſee the profile ABCD, Fig. 2.) and adjuſt to it a partition ST, of the ſame width, and that is fifteen inches deep from S to T; obſerve, that this partition will ſeparate the box into two diviſions, the upper of which muſt be one or two inches leſs than the under.

In the upper diviſion, and toward the extremity S of the partition ST, and croſs it, place a ſmall decoration KS, of the figure of the outward ſcene of a theatre, in which let there be an opening of ten inches wide, and eight inches high.

* If the dimenſions of the box be larger, the exhibition will be more perfect; and on the contrary, if it be ſmaller, it will be leſs perfect.

Behind

Behind this ſcene place the mirror KF, (Fig. 2.) in an angle of forty-five degrees, as in the common optical machines, and obſerve that it be of the ſame width with the box, and large enough to cover the overture of the front ſcene, when the eye is placed at the tranſparent glaſs E.

Decorate the interior ſpace K S B T, with ſuch different paintings as you ſhall judge will contribute moſt to the pleaſure of the exhibition. Cover the top of the box, from K to B, with a frame in which is a glaſs lined with gauze, that the light may enter the part K S B T. This firſt conſtruction being made in the proportions and with the precautions here laid down, you are next to place the inclined plane, hereafter deſcribed, which muſt be of a ſize to enter this edifice by a back door made at G H.

Conſtruction of the inclined plane.

This plane ſhould incline to the baſe of the ſtructure in an angle of about thirty degrees,

degrees*, that is, it ſhould be raiſed about one third of the ſpace toward the perpendicular, and muſt be ſupported on its ſides by two triangular props, placed at I M L.

On that part of this plane with faces the mirror K F, draw ſome pleaſing ſubject, as for example, a garden ornamented with bowers; or a piece of architecture, &c. in ſuch manner that it may appear regular when ſeen at E, by reflection from the inclined mirror †.

In this plane form a groove made of two thin ſlips of copper, very little elevated above the ſurface; let this groove be ſo diſpoſed that the ball in going from the

* If the ball that is to run down this plane make many turnings, the plane ſhould then have a greater inclination.

† This drawing need not differ much from the common method; for as the plane IM is but little inclined, it will be only neceſſary to draw the objects a little higher: their width may remain the ſame.

top

top may make various windings, over ſuch parts of the drawings as you ſhall think fit, and at laſt deſcending near the middle of its inferior ſide C D, (Fig. 3.) and running along the channel OP, (Fig. 2.) it may fall into a part made to receive it in the wheel hereafter deſcribed.

Provide yourſelf with ſeveral ivory balls of ſomething more than half an inch diameter, which are to run freely in the groove above deſcribed.

On the inſide of this box, towards R, place two ſmall tin candleſticks, in which put two wax candles to enlighten the inclined plane*; there muſt be a door by which you may take them out at pleaſure: fix over them a cover of tin, to which there muſt be a funnel to carry the ſmoke out of the edifice.

* To theſe candleſticks may be joined reflectors, ſo diſpoſed as to throw all the light on the inclined plane.

Con-

Construction of the wheel for remounting the balls incessantly.

In the centre of the toothed wheel A, (Pl. IX. Fig. 5.) place a barrel with a spring, and let it be also in the centre of the brass rod FG. The pinion of the wheel B is to take the teeth of the first wheel A; and its teeth are to turn the fly C, whose wings must be moveable, that by being more or less inclined, they may accelerate or retard the motion of the machine.

To the wheel A let there be fixed two brass rods*, and at the extremity of each there must be a box D, (see the profile Fig. 6.) whose overture M N is closed by a valve H, that moves freely on the point I: the axis of this valve must come out beyond the surface of the box, that the check L may be there placed, which

* The axis of this wheel should project, that it may be wound up by a key, in the same manner as a clock.

should

ſhould move freely, and at the ſame time with the valve. Theſe boxes muſt be large enough to contain, each of them, one of the balls, that are, as we have ſaid, to roll on the inclined plane, and that it may enter at the ſide M of the valve, which muſt then cloſe. The ſides of theſe boxes muſt incline, as in Fig. 5.

Obſerve alſo, that this wheel muſt be of a proper ſize to place at the back of this machine, near that part where the inclined plane is placed, (ſee Fig. 4.) that it may not only receive in its revolving boxes the balls, that after having rolled on the plane, paſs out by the groove OP, (Fig. 2.) but may alſo raiſe them again to the height C, (Fig. 4.) where there ſhould be a ſmall channel to receive and conduct them to the top of the inclined plane. Remark, alſo, that toward the part M there muſt be a little iron catch, that may ſucceſſively ſtop the cheeks L, (Fig. 6.) which are fixed to the axis of the valves, that it may

may give time to the ball to paſs into the box at the part M, and diſcharge the check L: in like manner when the box comes to the height of the groove that is to conduct the ball to the inclined plane, there muſt be another catch to open the valve and diſcharge the ball.

The wheel being thus placed, at the back of the machine, and the ſpring wound up, the balls will inceſſantly deſcend and remount till the ſpring in the box at the axis of the wheel is quite unbent*.

When a ball is put into the groove at the top and runs down the inclined plane, he that looks into the glaſs placed in front of the box, will imagine that it aſcends by various turnings, and goes out at the top of the edifice. The appearance will become the more pleaſing as the different

* There ſhould be a caſe over this wheel, with a door to open, that the contrivance may be quite free from detection.

windings

windings of the ball are properly adapted to the ſubject painted on the inclined plane. This piece when executed with care, produces a very remarkable illuſion, and is one of the moſt pleaſing Recreations of catoptrics.

RECREATION XXVI.

The ſame exhibition by a double reflection.

THIS differs from the foregoing by having a mirror inclined in an angle of forty-five degrees, (ſee Plate IX. Fig. 2.) in the room of the inclined plane, and by having the plane on which the balls roll placed near the part of the box T D.

There may be placed, moreover, toward S T, and in a poſition almoſt horizontal, little columns, arbours, or other objects, made of braſs wire, at equal diſtances*,

* This wire ſhould have a ſmall inclination, which may be two tenths of an inch for every foot; and the diſtance between the wires ſhould be ſomething leſs than the diameter of the balls.

and

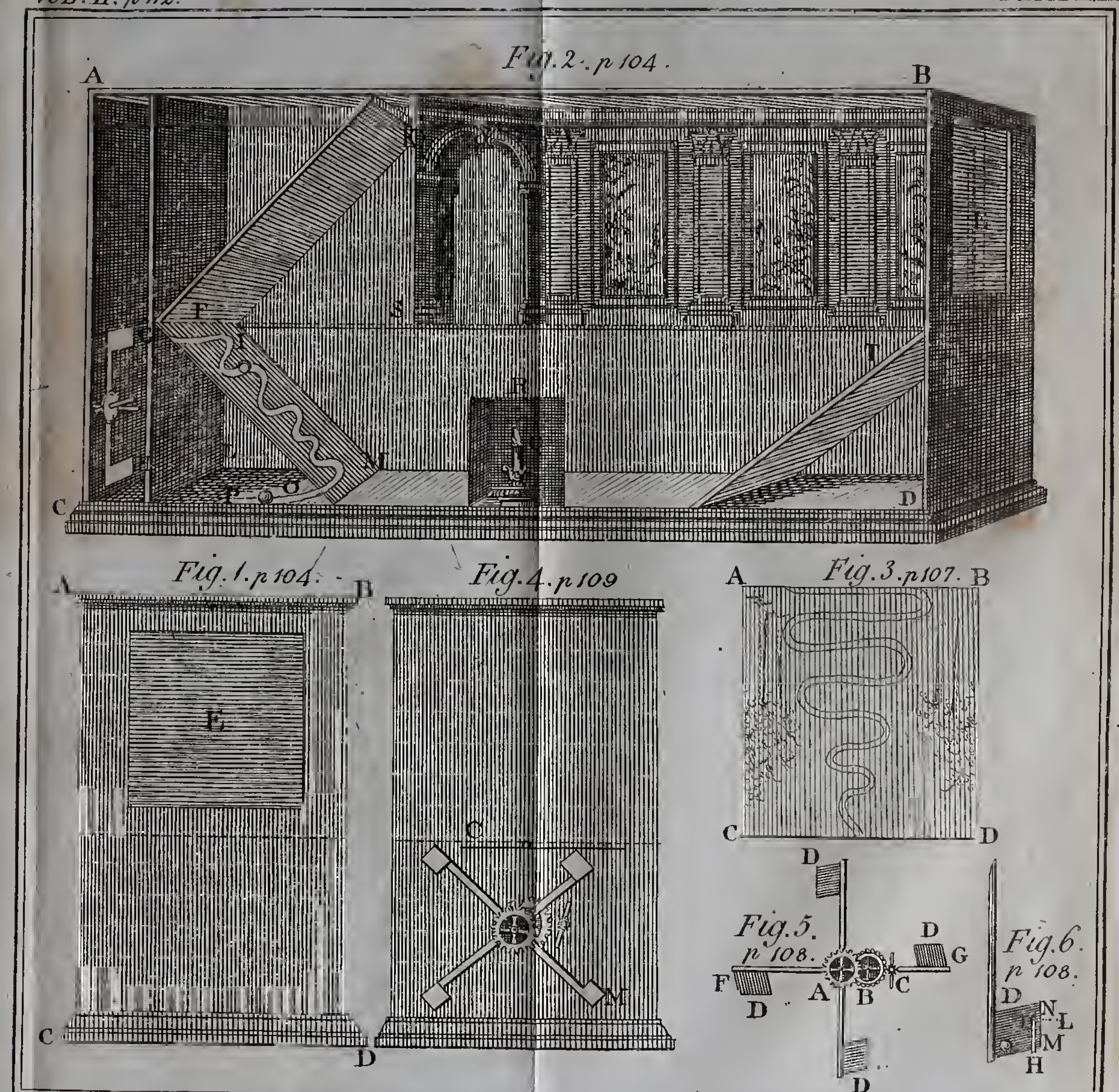
and joined together at the bottom by ſemi-circles, which muſt be ſo contrived as not to obſtruct the courſe of the ball.

If there be ſufficient room, you may place, under the former, another range of wires, that have a ſimilar diſpoſition, ſo that the ball, after having run over the firſt, may deſcend to the other, which will have a remarkable effect; as the balls will ſeem to rencounter and paſs over each other. There muſt then be two conductors, ſo that one ball may enter at one ſide, and the other at the oppoſite ſide. There ſhould alſo be a third conductor, which, after the ball has paſſed over the firſt piece, may carry it to the top of the inclined plane, placed oppoſite the ſecond mirror, that it may then paſs through all its windings.

Note. Theſe exhibitions may be varied at pleaſure, as that depends entirely on the taſte and invention of thoſe that con-

ſtruct

PLATE IX.



J. Lodge sculp.

ſtruct them. You ſhould obſerve to give but a very ſmalll inclination to the grooves in which the balls run. Theſe balls may be of ivory painted, as thoſe of braſs make too much noiſe in the box, and are ſubject to break the inclined mirror, when by chance they jump out of the groove and fall on it.

The grooves ſhould be concealed as much as poſſible by paintings or ornaments. They ſhould be either of braſs, tin or thin paſteboard. In a word, too much care cannot be taken in conducting exhibitions of this nature.

RECREATION XXVII.

To deſcribe on a plane ſurſace an irregular figure, which ſhall appear regular when placed oppoſite a multiplying glaſs, and ſeen by reflection through an aperture made in the center of the drawing.

WE ſhall not here lay down the geometric manner of drawing this figure, for it would not only be very complicate, and extremely difficult to execute, but when done could not ſucceed, on account of the impoſſibility of procuring glaſſes of this ſort, whoſe planes are equal ly inclined and perfectly regular.

CONSTRUCTION.

Procure of an able artiſt a mirror of metal (Plate X. Fig. 3.) whoſe baſe is a hexagon of about two inches and a half in dameter, and about half an inch thick at its center. Let the faces of this mirror be very truly cut, their angles very ſharp, and

and their ſurfaces highly poliſhed. Cement this mirror to a ſtand of about half an inch thick, and let it be firmly joined by means of a ſcrew, at the point A, (Fig. 4.) which ſhould be eight or nine inches high; and let the ſtand be ſolidly fixed on the top of the box BC*.

At the end C of this box (Fig. 4.) place an upright frame with a groove, which is to remain there, and in which are to be placed the deſigns, of about fifteen inches ſquare, containing the different diſtorted figures that are to appear regular, when ſeen in the glaſs, which, as appears by the figure, will then be oppoſite to it.

In the center of the drawing make a hole of about three tenths of an inch in diameter, through which the mirror may be entirely ſeen, and which ſhould be placed

* This box may have a drawer, to contain the different paintings that are to be ſeen by the mirror: it may be eight or nine inches wide, and fifteen inches deep.

exactly oppoſite that hole, with its baſe parallel to the drawing or picture.

Draw on a paper or paſteboard the geometric plan of the multiplying glaſs, (ſee Fig. 6.) and on that draw the deſign you would have ſeen in the mirror. Theſe preparations being made with great attention, that is, the mirror being properly fixed, and the drawing rightly adjuſted, look at the mirror through the hole H, made in the drawing, and holding the ruler A B*, by its handle D, (ſee Fig. 5.) in your left hand, move it in different directions over the drawing till its ſide C appear to the eye (remaining conſtantly at H) to be exactly even with one of the ſides of the glaſs; there keep it fixed; and taking the eye from the hole, draw with a black lead pencil, that you have ready in the other hand, a line by the

* This ruler ſhould be about three or four inches long, very thin and black. It may be made of part of the ſpring of a clock.

ruler

ruler. Do the ſame by the other ſides of that face of the glaſs, and then the ſpace contained between thoſe two lines will be that on which you are to tranſpoſe that part of the deſign which is drawn on the correſponding face in Fig. 3.

Do the ſame by all the other faces of the glaſs, and you will then have twelve faces that will correſpond to thoſe of the mirror, and which altogether muſt conſequently contain the entire ſubject that is traced on Fig. 6.

Theſe ſpaces not differing much from thoſe of the mirror, it will be eaſy to trace the object that has been deſigned; it will be only neceſſary to number them, to prevent any miſtake; and to place the paper or paſteboard before the mirror, after you have lightly traced the deſign; and inſpect it by the hole H, that you may diſcover and rectify any errors that may have been made. Theſe ſpaces may alſo be ſubdi-

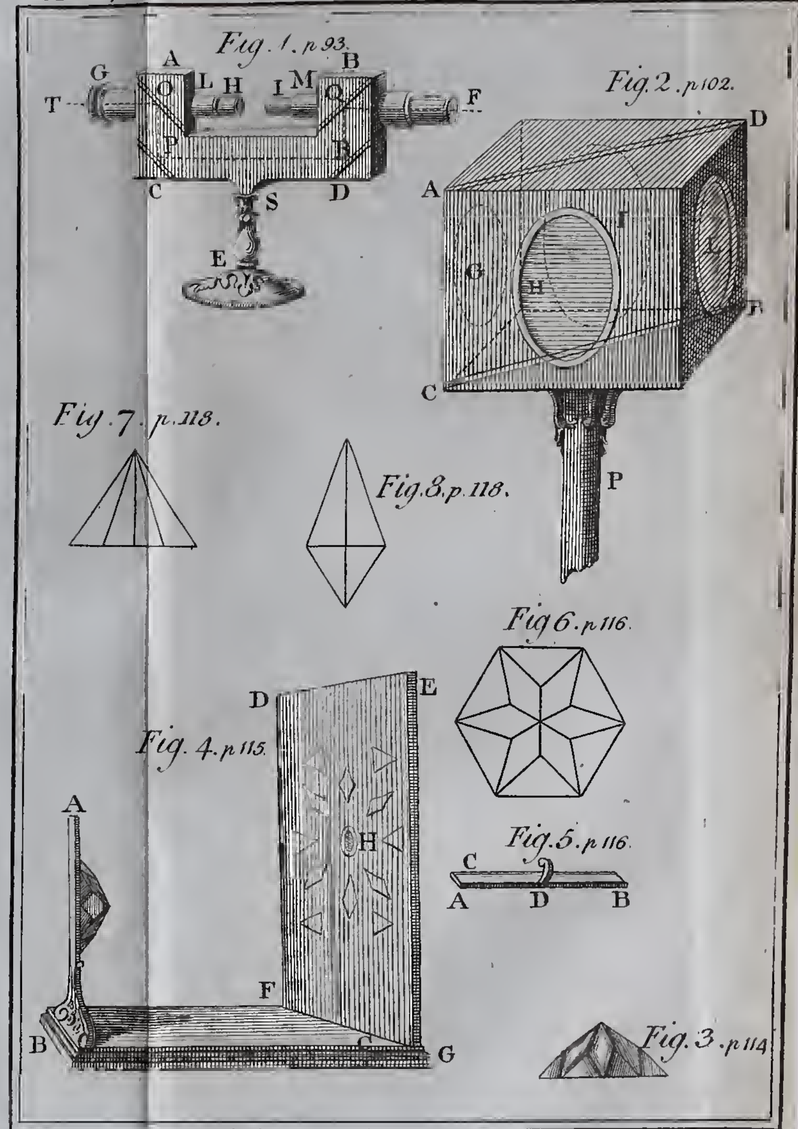
vided, as well on the defign as the diftorted figure, in the manner expreffed in Fig. 7, 8; and by that means the tranfpofition will be made with ftill greater facility.

Laftly, you fhould fill up the vacant parts on the pafteboard with figures that have no analogy with thofe in the original defign, and by that means render it ftill more furprifing.

This experiment will produce a moft agreeable illufion to thofe who are ignorant of the manner in which it is performed; for, when looking at the point H, they cannot difcover the leaft refemblance between what they fee in the mirror, and the general defign on the pafteboard.

Obferve, this drawing may alfo be traced correctly enough by means of a lamp, placed at the point of view H, taking care to enclofe it in a tin cafe, and

to



J. Lodge sculp.

to adjuſt to it a tube of about an inch in diameter, and three or four inches long, that can be protracted or ſhortened at pleaſure. When you uſe this method, a hole muſt be made in the paper, large enough to admit the end of the tube ; ſo that the light falling on the ſeveral faces of the glaſs, they may be reflected on the paper, and ſhow where each of them is to be traced. By this method the time ſpent in finding them by the ruler is ſaved ; and if the light be ſteady, the drawing will anſwer very well. You may alſo draw on the mirror, with ſoot, tempered with fine white lead, all the ſtrokes of the deſign, and by that means ſtill ſhorten the execution of the drawing.

RECREATION XXVIII.

To describe on a plane surface a deformed figure, which shall appear regular when viewed by reflection in a cylindrical mirror.

THE geometric method of describing this irregular figure, being, as in the last Recreation, not only extremely difficult, on account of its different curves, but also liable to error from the want of regularity in making the mirrors; we shall here shew another method of describing it, far less learned indeed, but much more concise, and easily practicable by those who have not a profound knowledge of geometry, but are yet desirous of drawing these sorts of anamorphoses

Let A B C D be the cylindrical mirror, (Plate XI. Fig. 1.) in which you would see, from

from the point of view E, the deformed object painted on the board FG, in a regular form.

On a paper, or pasteboard, draw the circle A (Fig. 2.) equal to the base BD of the cylindric mirror; and taking the point B for the distance of the point of view from the mirror, draw the line AB, which must pass through A, the center of the circle. Then draw the two lines BC and BD.

Divide the line CD into six equal parts, and draw from the point of view B, the lines B *i*, which by cutting one of the sides of the circle, will determine the points on which you are to erect the parallel perpendiculars, which may be done by a ruler; making use of an opaque colour that will effectually obscure those parts of the cylinder where they are drawn*.

* You may use soot and white lead ground together with gum, after having traced the lines with a crayon.

These

Thefe firft divifions being regularly made, divide about two thirds of the height of the fide CD, of the cylinder, into ten or twelve parts, refpectively equal to thofe of the diameter of the circle (Fig. 2.) and from the point of view E, draw the lines E *l*, which paffing through all the points of divifion, muft be continued to the other fide of the cylinder. On the two oppofite fides of the cylinder mark the different heights of the feveral divifions, and through thofe points draw the oval figures *i l*, making ufe of the fame colour as before.

Take a paper ABCD (Fig. 3.) whofe two fides AB and CD muft be divided into fix equal parts, and thofe of AC and BD into ten or twelve equal parts, on which you are to draw the figure as you would have it appear to the eye when viewed in the cylindric mirror. At the point of view E, place a lamp fo difpofed that its light may fall on the cylindric mirror only.

When

When you have fixed the cylinder on the pafteboard F G (Fig. 1.) and the lamp is placed at E, fo that its light cannot fall on the pafteboard, but by reflection, all the ftrokes on the cylinder will then appear on the board, and may be eafily traced with a pencil. By this means the board will be divided into as many irregular fpaces, as there are regular divifions in the parallelogram (Fig. 8.) If, therefore, you transfer to each of thofe fpaces the ftrokes of the defign that is on the parallelogram, it will appear quite deformed on the pafteboard, and quite regular when feen from the point of view E, efpecially if due attention be had to drawing the outlines of the figure.

Note, The point of view fhould be four or five inches above the upper part of the mirror, that you may not be obliged to make ufe of a very large pafteboard: it fhould not, however, be much higher, as then the figure on the board would not be fufficiently deformed.

By

By this method you may alſo draw irregular figures to be ſeen in a priſm, or any other ſort of mirror, provided they can be traced and illuminated*.

Obſerve, if you are deſirous of painting theſe ſorts of anamorphoſes to advantage, you muſt not overcharge thoſe parts with colour that are moſt diſtended, for when they become contracted in the mirror the colours appear unnatural. In a word, great attention is neceſſary in drawing and painting theſe ſubject, as on that the ſucceſs principally depends.

* The geometric method of drawing deformed objects to be ſeen in a priſm, will be found at large in the treatiſe of Abbé Nollet.

RECREATION XXIX.

Optical appearances.

OF all our ſenſes the ſight is certaily ſubject to the greateſt illuſion. The various writers on optics have deſcribed a great number of inſtances in which it deceives us, and have conſtantly endeavoured to inveſtigate the cauſes, to explain their effects, and to reconcile appearance with reality. We every day diſcover new phenomena, and doubtleſs many more are reſerved for poſterity. It frequently happens, moreover, that a diſcovery which at firſt ſeemed of little conſequence, has led to matters of the higheſt importance.

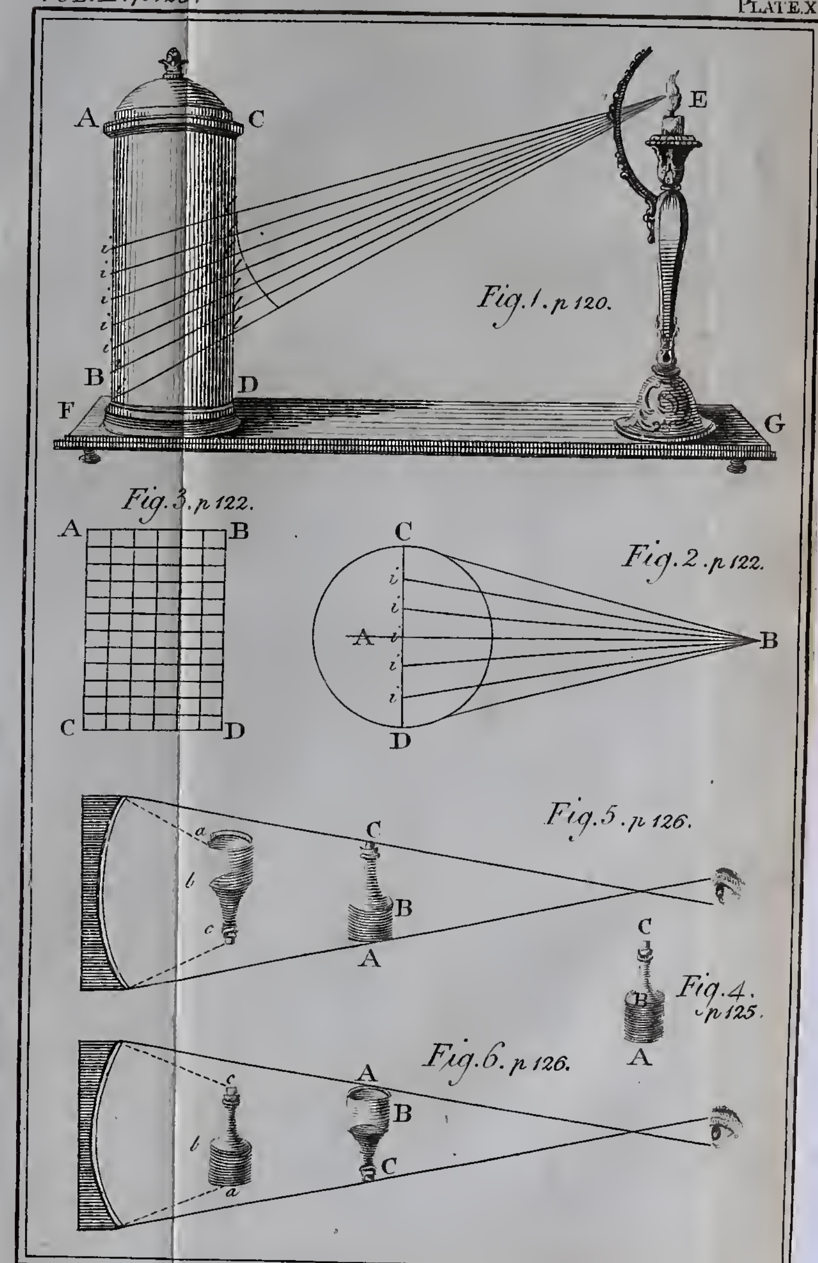
Take a glaſs bottle A, (Pl. XI. Fig. 4.) and fill it with water to the point B; leave the upper part BC, empty, and cork it in the common manner. Place this bottle oppoſite a concave mirror, and beyond its focus, that it may appear reverſed, and before

fore the mirror (see aphorism 4. page 65.) Place yourself still farther distant than the bottle, and it will appear to you in the situation *a*, *b*, c, (Fig. 5.)

Now it is remarkable in this apparent bottle, that the water, which, according to all the laws of catoptrics, and all the experiments made on other objects, should appear at *a b*, appears on the contrary at *b c*, and consequently the part *a b* appears empty.

If the bottle be inverted and placed before the mirror (as in Fig. 6.) its image will appear in its natural, erect position; and the water, which is in reality at BC, will appear at *a b*.

If while the bottle is inverted it be uncorked, and the water run gently out, it will appear that while the part BC is emptying, that of *a b* in the image is filling; and what is likewise very remarkable,



J. Lodge sculp.

able, as ſoon as the bottle is empty the illuſion ceaſes, the image alſo appearing entirely empty. If the bottle likewiſe be quite full there is no illuſion.

If while the bottle is held inverted, and partly empty, ſome drops of water fall from the bottom A towards BC, it ſeems in the image as if there were formed at the bottom of the part *a b*, bubbles of air that roſe from *a* to *b*; which is the part that ſeems full of water. All theſe phenomena conſtantly appear.

The remarkable circumſtances in this experiment, are, firſt, not only to ſee an object where it is not, but alſo where its image is not; and ſecondly, that of two objects which are really in the ſame place, as the ſurface of the bottle and the water it contains, the one is ſeen at one place, and the other at another; and to ſee the bottle in the place of its image, and the water where neither it, nor its image, are.

Note,

Note, It has been conjectured, with ſome appearance of reaſon, that this illuſion ariſes partly from our not being accuſtomed to ſee water ſuſpended in a bottle with the neck downward, and partly from the reſemblance there is between the colour of the air and that of water, which induces us to imagine that we ſee them where they uſually are; and this is rendered more probable by putting any coloured liquor into the bottle, for that will appear in its proper place (M. Guyot.)

RECREATION XXX.

The perſpective mirror.

PROVIDE a box ABCD (Pl. XII. Fig. 1.) of about two feet long, fifteen inches wide, and twelve inches high. At the end AC place a concave mirror, the focus of whoſe parallel rays is at eighteen inches from the reflecting ſurface. At IL place a paſteboard blacked, in which a hole

a hole is cut ſufficiently large to ſee on the mirror H, the object placed at BEFD.

Cover the top of the box, from A to I, cloſe, that the mirror H, may be entirely darkened. The other part I B, muſt be covered with a glaſs, under which is placed a gauze.

Make an aperture at G, near the top of the ſide E B; beneath which, on the inſide, place, in ſucceſſion, paintings of different ſubjects, as viſtas, landſcapes, &c. ſo that they may be in front of the mirror H. Let the box be ſo placed that the object may be ſtrongly illumined by the ſun, or by wax lights placed under the encloſed part of the box A I.

By this ſimple conſtruction the objects placed at G D will be thrown into their natural perſpective, and if the ſubjects be properly choſe, the appearance will be altogether as pleaſing as in optical machines of a much more complicated form.

Note, A glaſs miror ſhould be always here uſed, as thoſe of metal do not repreſent the objects with equal vivacity, and are beſide ſubject to tarniſh. It is alſo neceſſary that the box be ſufficiently large, that you may not be obliged to uſe a mirror whoſe focus is too ſhort; for in that caſe, the right lines near the border of the picture will appear bent in the mirror, which will have a diſagreeable effect, and cannot be avoided.

RECREATION XXXI.

To ſet fire to a combuſtible body, by the reflection of two concave mirrors.

THE rays of a luminous body placed in the focus of a concave mirror being reflected in parallel lines, if a ſecond mirror be placed diametrically oppoſite the firſt, it will, by collecting thoſe rays in its focus, ſet fire to a combuſtible body.

Place two concave mirrors, A and B (Pl. XII, Fig. 2.) at about twelve or fifteen feet

feet diſtance from each other, and let the axis of each of them be in the ſame line. In the focus C, of one of them, place a live coal, and in the focus D of the other, ſome gunpowder. With a pair of double bellows, which make a continual blaſt, keep conſtantly blowing the coal, and notwithſtanding the diſtance between them the powder will preſently take fire.

It is not neceſſary that theſe mirrors be of metal or glaſs, thoſe made of wood or paſteboard, gilded, will produce the exploſion, which has ſometimes taken effect at the diſtance of fifty feet, when mirrors of eighteen inches or two feet diameter have been uſed.

This experiment ſucceeds with more difficulty at great diſtances; which may proceed from the moiſture in a large quantity of air. It would doubtleſs take effect more readily, if a tin tube, of an equal diameter with the mirrors, were to placed between them.

RECREATION XXXII.

The real apparation.

BEHIND the partition A B (Pl. XII. Fig. 3.) place, in a poſition ſomething oblique, the concave mirror E F, which muſt be at leaſt ten inches in diameter, and its diſtance from the partition equal to three-fourths of the diſtance of its center.

In the partition make an opening of ſeven or eight inches, either ſquare or circular: it muſt face the mirror; and be of the ſame height with it. Behind this partition place a ſtrong light, ſo diſpoſed that it may not be ſeen at the opening, and may illumine an object placed at C, without throwing any light on the mirror.

Beneath the aperture in the partition place the object C, that you intend ſhall appear on the outſide of the partition, in an inverted poſition; and which we will

ſuppoſe

ſuppoſe to be a flower. Before the partition, and beneath the aperture, place a little flower-pot D, the top of which ſhould be even with the bottom of the aperture, that the eye, placed at G, may ſee the flower in the ſame poſition as if its ſtalk came out of the pot.

Take care to paint the ſpace between the back part of the partition and the mirror black, to prevent any reflections of light from being thrown on the mirror; in a word, ſo diſpoſe the whole that it may be as little enlightened as poſſible.

When a perſon is placed at the point G, he will perceive the flower that is behind the partition, at the top of the pot at D, but on putting out his hand to pluck it, he will find that he attempts to graſp a ſhadow.

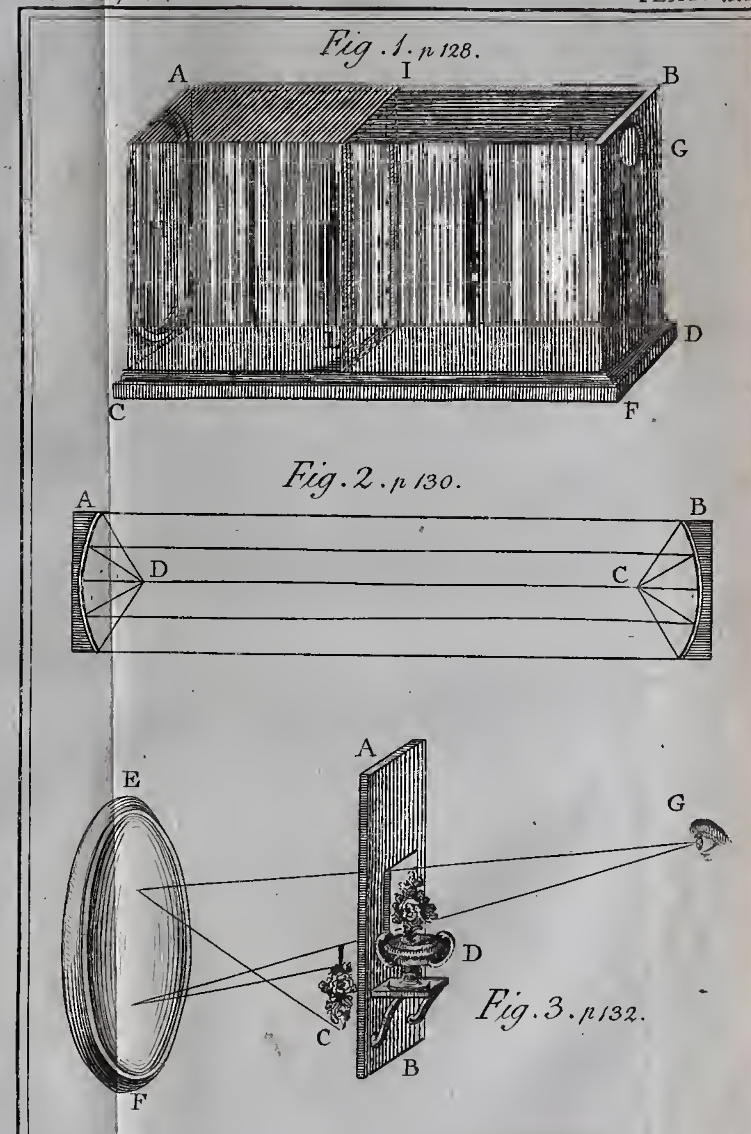
Obſervation.

The phenomena that may be produced by means of concave mirrors are highly

curious and aſtoniſhing. By their aid ſpectres of various kinds may be exhibited. Suppoſe, for example, you were to tell any one, that at ſuch an hour, and in ſuch a place, he ſhould ſee the apparition of an abſent or deceaſed friend (of whoſe portrait you are in poſſeſſion.) In order to produce this phantom, inſtead of the hole in the partition A B, in the laſt figure, there muſt be a door, which opens into an apartment to which there is a conſiderable deſcent. Under that door you are to place the portrait, which muſt be inverted and ſtrongly illuminated, that it may be lively reflected by the mirror, which muſt be large and well poliſhed. Then having introduced the incredulous ſpectator at another door, and placed him in the proper point of view, you ſuddenly throw open the door at A B, when to his great aſtoniſhment, he will immediately ſee the apparition of his friend.

It will be objected, perhaps, that this is not a perfect apparition, becauſe it is only viſible

Vol. I. p 134. PLATE XII.



J. Lodge Sculp.

visible at one point of view, and by one person. But it should be remembered, that it was an established maxim in the last centuries, that a spectre might be visible to one person and not to others. So Shakespeare makes both Hamlet and Macbeth see apparitions that were not visible to others, present at the same time. It is not unlikely, moreover, that this maxim took its rise from certain apparitions of this kind that were raised by the monks, to serve some purposes they called religious; as they alone were in possession of what little learning there then was in the world.

Nothing here said is intended to invalidate the belief that separate spirits may hold converse with men. He must be either very weak or very wicked, who can wish to disbelieve an opinion that is so highly honourable and advantageous to humanity.

There is one phenomenon we must not here omit; for tho' it be common enough

it is alſo pleaſing, and eaſy to be perform-ed. If you place yourſelf before a concave mirror and at a proper diſtance, your figure will appear inverted, and if you ſtretch out your hand toward the mirror, you will perceive another hand that ſeems to meet and join it, though imperceptible to the touch. If inſtead of your hand you make uſe of a drawn ſword, and preſent it in ſuch manner that its point may be direct-ed toward the focus of the parallel rays of the mirror, another ſword will appear, and ſeem to encounter that in your hand. You are to obſerve, that to make this ex-periment ſucceed well, you muſt have a mirror of at leaſt a foot in diameter, that you may ſee yourſelf in part. If you have a mirror large enough to ſee your whole perſon, the illuſion will be much more ſtriking. This phenomenon, with which ſo much parade has been made by ſome modern experimental phi-loſophers, was deſcribed by Baptiſta Porta more than 200 years ſince.

CHRO-

CHROMATICS.

CHROMATICS is that part of optics which explains the ſeveral properties of the colours of light, and of natural bodies.

DEFINITIONS.

1. Thoſe rays of light that are all equally refrangible, are called ſimple or homogeneal rays.

2. Thoſe rays that have different degrees of refrangibility, are called compound, or heterogeneal*.

3. The colours of homogeneal light are called primary or ſimple colours: and

4. Thoſe of heterogeneal light, ſecondary or compound colours.

5. A ſpectrum is a coloured image of the ſun, produced by the refraction of a ray of light let into a dark chamber.

* The terms homogeneal and heterogeneal are derived from the Greek words *omos, the ſame*; *eteros, another*; and *genos, kind* or *ſpecies*.

6. A

6. A prifm is a glafs body, whofe two ends are fimilar and parallel triangles, and its three fides regular planes.

APHORISMS.

1. All the colours in nature proceed from the rays of light.

2. There are feven primary colours, which are red, orange, yellow, green, blue, indigo, and violet.

3. Every ray of light may be feparated into the feven primary colours.

4. The rays of light in paffing through the fame medium have different degrees of refrangibility.

5. The difference in the colours of light arifes from its different refrangibility, that which is the leaft refrangible producing red, and that which is the moft refrangible, violet*.

* It is conjectured that the different refrangibility in the rays of light proceeds from their different magnitude: thofe of red light, being the largeft, make

6. By compounding any two of the primary colours, as red and yellow, or yellow and blue, the intermediate colour, as orange or green, may be produced.

7. The colours of bodies arife from the difpofitions to reflect one fort of rays, and to abforb the other. Thofe that reflect the leaft refrangible rays appearing red; and thofe that reflect the moft refrangible, violet*.

make the ftrongeft impreffion on the retina; and thofe of violet, being the fmalleft, make the weakeft impreffion.

* It appears highly probable, from obfervations made by Sir Ifaac Newton, that the difpofition of bodies to reflect the different rays of light, arifes from the different fize of their particles. Thus, the azure colour of the fky, and the moft luminous white, as that of metals, he fuppofes to be produced by particles of the firft order; but if the white be lefs intenfe, as that of linen, paper, and fuch like fubftances, he conjectures that it arifes from a mixture of particles of all orders. The green of vegetables he fuppofes to proceed from the third order, and the particles that caufe blacknefs, to be fmaller than thofe that produce any of the colours.

8. Such

8. Such bodies as reflect two or more sorts of rays, appear of various colours.

9. The whiteneſs of bodies ariſes from their diſpoſition to reflect all the rays of light promiſcuouſly.

10. The blackneſs of bodies proceeds from their incapacity to reflect any of the rays of light *.

RECREATION XXXIII.

Out of a ſingle colourleſs ray of light to produce ſeven other rays, which ſhall paint, on a white body, the ſeven primary colours of nature.

PROCURE of an optician a large glaſs priſm DEF, (Plate XIII. Fig. 1.) well poliſhed, two of whoſe ſides muſt contain an angle of about ſixty-four degrees. Make a room quite dark, and in the window ſhutter AB, cut a round hole, about

* From hence it ariſes that black bodies, when expoſed to the ſun, become ſooner heated than all others.

one-

one-third of an inch in diameter at C, through which a ray of light LI paſſing, falls on the priſm DEF, by that it is refracted out of the direction IT, in which it would have proceeded, into another G H, and falling on the paper MNSX, will there form an oblong ſpectrum PQ, whoſe ends will be ſemicircular, and its ſides ſtrait; and if the diſtance of the priſm from the paper be about eighteen feet, it will be ten inches long, and two inches wide.

Now this ſpectrum will exhibit all the primary colours; for the rays between P and V, which are the moſt refracted, will paint a deep violet; thoſe between V and I, indigo; thoſe between I and B, blue; thoſe between B and G, green; thoſe between G and Y, yellow; thoſe between Y and O, orange; and thoſe between O and R, being the leaſt refracted, an intenſe red*. The colours between theſe

* For this reaſon it is that the rays which are near the edges of a lens have different degrees of refraction,

ſpaces will not be every where equally intenſe, but will incline to the neighbouring colour; thus the part of the orange next to R, will incline to a red, and that next to Y, to a yellow; and ſo of the reſt.

RECREATION XXXIV.

From two or more of the primary colours, to compoſe others that ſhall, in appearance, reſemble thoſe of the former.

BY mixing the two homogeneal colours red and yellow, an orange will be produced, ſimilar in appearance to that in the ſeries of primary colours; but the light of the one being homogeneal, and, that of the other heterogeneal, if the former be viewed through a priſm it will remain unaltered, but the other will be reſolved into its component colours, red and yellow. In like manner other contiguous

refraction, and tinge the object with different colours.

ho-

homogeneal colours may compound new colours; as by mixing yellow and green, a colour between them is formed; and if blue be added, there will appear a green that is the middle colour of thoſe three. For the yellow and blue, if they are equal in quantity, will draw the intermediate green equally toward them, and keep it, as it were in equilibrio, that it verge not more to the one than the other. To this compound green there may be added ſome red and violet, and yet the green will not immediately ceaſe, but grow leſs vivid; till by adding more red and violet it will become more diluted, and at laſt, by the prevalence of the added colours, it will be overcome, and turned into whiteneſs or ſome other colour.

In like manner if the ſun's white, compoſed of all kind of rays, be added to any homogeneal colour, that colour will not vaniſh, nor change its ſpecies, but be diluted, and by adding more white, it will

become

become continually more diluted. Laſtly, if red and violet be mixed, there will be generated, according to their various proportions, various purples, ſuch as are not like in appearance, to the colour of any homogeneal light: and of theſe purples, mixed with blue and yellow, other new colours may be compoſed.

RECREATION XXXV.

Out of three of the primary colours, red, yellow, and blue, to produce all the other priſmatic colours, and all that are intermediate to them.

PROVIDE, three panes of glaſs of about five inches ſquare, (ſee Plate XIII. Fig. 2.) and divide each of them, by parallel lines, into five equal parts.

Take three ſheets of very thin paper, which you muſt paint, lightly, one blue, another yellow, and the third red*. Then

* You muſt uſe water colours for this purpoſe: the blue may be that of Pruſſia, and very bright; the

pafte on one of the glaffes five pieces of the red paper, one of which muft cover the whole glafs, the fecond only the four lower divifions, the third the three lower, the fourth the two loweft, and the fifth the laft divifion only. On the other two glaffes five pieces of the blue and yellow papers muft be pafted in like manner.

You muft alfo have a box of about fix inches long, and the fame depth and width as the glaffes: it muft be black on the infide: let one end be quite open, and in the oppofite end there muft be a hole large enough to fee the glaffes completely. It muft alfo open at the top, that the glaffes may be placed in it conveniently.

When you have put any one of thefe glaffes in the box, and the open end is

the red, carmine; and the yellow gambooge, mixed with a little faffron. Thefe colours muft be laid very light and even, on both fides of the paper.

turned toward the ſun, you will ſee five diſtinct ſhades of the colour it contains.

If you place the blue and yellow glaſſes together, in a ſimilar direction, you will ſee five ſhades of green diſtinctly formed. When the blue and red glaſſes are placed, a bright violet will be produced; and by the red and yellow the ſeveral ſhades of orange.

If, inſtead of placing theſe glaſſes in a ſimilar poſition, you place the ſide A B of the yellow glaſs, againſt the ſide B D of the blue, (Plate XIII. Fig. 3.) you will ſee all the various greens that are produced by nature*; if the blue and red glaſſes be placed in that manner, you will have all the poſſible varieties of purples, violets, &c. and laſtly, if the red and orange

* In the firſt poſition of the glaſſes the quantity of blue and yellow being equal, the ſame ſort of green was conſtantly viſible: but by thus inverting the glaſſes, the quantity of the colours being conſtantly unequal, a very pleaſing variety of tints is produced.

glaſſes

glaſſes be ſo placed, there will be all the intermediate colours, as the marygold, aurora, &c.

RECREATION XXXVI.

By means of the three primary colours, red, yellow, and blue, together with light and ſhade, to produce all the gradations of the priſmatic colours.

ON ſeven ſquare panes of glaſs paſte papers that are painted with the ſeven priſmatic colours, in the ſame manner as in the laſt Recreation. The colours for the orange, green, indigo, and violet, may be made by mixing the other three. Then with biſtre*, well diluted, ſhade a ſheet of very thin paper, by laying it light on both its ſides. With pieces of this paper cover four-fifths of a glaſs, of the ſame ſize with the others, by laying one piece on the four loweſt diviſions, another on

* The biſtre here uſed muſt be made of ſoot, not that in ſtone.

the three loweſt, a third on the two loweſt, and the fourth on the loweſt diviſion only: and leaving the top diviſion quite uncovered.

When one of the coloured glaſſes is placed in the box, together with the glaſs of ſhades, ſo that the ſide AB of the one be applied to the ſide BD of the other, as in Fig. 3. of the laſt Recreation, the ſeveral gradations of colours will appear ſhaded in the ſame manner as a drapery judiciouſly painted with that colour.

It is on this principle that certain French artiſts have proceeded in their endeavours to imitate, by deſigns printed in colours, paintings in oil: which they do by four plates of the ſame ſize, on each of which is engraved the ſame deſign. One of theſe contains all the ſhades that are to be repreſented, and which are painted either black, or with a dark grey. One of the three other plates is coloured with blue, another

another with red, and the third with yellow: each of them being engraved in thoſe parts only which are to repreſent that colour *, and the engraving is either ſtronger or weaker, in proportion to the tone of colour that is to be repreſented †.

Theſe four plates are then paſſed alternately under the preſs, and the mixture of their colours produces a print that bears

* When a red drapery is required, it is engraved on the plate aſſigned to that colour; and ſo of yellow and blue: but if one of the other colours be wanting, ſuppoſe violet, it muſt be engraved on thoſe that print the red and blue: and ſo of the reſt. The plates of this kind have been hitherto engraved in the manner of mezzotinto, but theſe, unleſs they are ſkilfully managed, ſoon become ſmutty. Engravings in the manner of the crayon, would perhaps anſwer better.

† The principal difficulty in this ſort of engraving ariſes from want of a ſkilful management, in giving each plate that preciſe degree of engraving which will produce the tone of colour required. If a bright green is to be repreſented, there ſhould be an equal quantity of graving on the red and yellow plates: but if an olive green, the yellow plate ſhould be engraved much deeper than the red.

no ſmall reſemblance to a painting. It muſt be confeſſed, however, that what has been hitherto done of this kind, falls far ſhort of that degree of perfection, of which this art appears ſuſceptible. If they who engrave the beſt in the manner of the crayon, were to apply themſelves to this art, there is reaſon to expect they would produce far more finiſhed pieces than we have hitherto ſeen.

RECREATION XXXVII.

The magical priſm.

MAKE a hole in the window-ſhutter of a dark room, through which a broad beam of light may paſs, that is to be refracted by the large glaſs priſm A B C, (Plate XIII. Fig. 4.) which may be made of pieces of mirrors cemented together, and filled with water.

Provide another priſm D E F, made of three pieces of wood: through the middle of

of this there muſt paſs an axis on which it is to revolve. This priſm muſt be covered with white paper, and each of its ſides cut through in ſeveral places ſo as to repreſent different figures, and thoſe of each ſide ſhould likewiſe be different. The inſide of this priſm is to be hollow, and made quite black, that it may not reflect any of the light that paſſes through the ſides into it.

When this priſm is placed near to that of glaſs, as in the figure, with one of its ſides EF, perpendicular to the ray of light, the figures on that ſide will appear perfectly white: but when it comes into the poſition *g h*, the figures will appear yellow and red, and when it is in the poſition *kl*, they will appear blue and violet. As the priſm is turned round its axis, the other ſides will have a ſimilar appearance. If inſtead of a priſm a four or five-ſided figure be here uſed, the appearances will be ſtill farther diverſified.

This phenomenon arifes from the different refrangibility of the rays of light. For when the fide EF is in the pofition $g h$, it is more ftrongly illuminated by the leaft refrangible rays, and wherever they are predominant, the object will appear red or yellow. But when it is on the pofition $k l$, the more refrangible rays being then predominant, it will appear tinged with blue and violet.

RECREATION XXXVIII.

The folar magic lantern.

PROCURE a box, of about a foot high and eighteen inches wide, or fuch other fimilar dimenfions as you fhall think fit; and about three inches deep. Two of the oppofite fides of this box muft be quite open, and in each of the other fides let there be a groove, wide enough to pafs a ftiff paper or pafteboard. This box muft be faftened againft a window on which the fun's rays fall direct. The reft of the window

dow ſhould be cloſed up, that no light may enter.

Provide ſeveral ſheets of ſtiff paper, which muſt be blacked on one ſide. On theſe papers cut out ſuch figures as you ſhall think proper, and placing them alternately in the grooves of the box, with their blacked ſides toward you, look at them through a large and clear glaſs priſm; and if the light be ſtrong, they will appear to be painted with the moſt lively colours in nature. If you cut on one of theſe papers the form of the rainbow, about three quarters of an inch wide, you will have a lively repreſentation of that in the atmoſphere.

This Recreation may be farther diverſified, by paſting very thin papers, lightly painted with different colours, over ſome of the parts that are cut out: which will appear to change their colours, when viewed through the priſm, and to ſtand out from

from the paper, at different diſtances, according to the different degrees of refrangibility, of the colours with which they are painted.

For greater convenience, the priſm may be placed in a ſtand on a table, at the height of your eye, and made to turn round on an axis, that when you have got an agreeable proſpect, you may fix it in that poſition. This experiment may be made at a trifling expence; and, if properly conducted, will afford no ſmall entertainment.

RECREATION XXXIX.

The artificial rainbow.

OPPOSITE a window into which the ſun ſhines direct, ſuſpend a glaſs globe filled with water, by a ſtring that runs over a pulley, ſo that the ſun's rays may fall on it. Then drawing the globe gradually up, when it comes to the height of

of about forty degrees*, you will ſee, by placing yourſelf in a proper ſituation, a purple colour in the glaſs, and by drawing it gradually up higher, the other priſmatic colours, blue, green, yellow, and red, will ſucceſſively appear; after which the colours will diſappear, till the globe is raiſed to about fifty degrees, when they will again be ſeen, but in an inverted order, the red appearing firſt, and the blue or violet laſt: and when the globe comes up to little more than fifty-four degrees they will totally vaniſh.

Theſe appearances ſerve to explain the phenomena of natural rainbows, of which there are frequently two; the one being about eight degrees above the other, and the order of their colours is inverted, as

* That is if you ſuppoſe an arch of a circle to be drawn from the horizon to the zenith, and divided into ninety equal parts or degrees, the globe muſt be raiſed to the height of forty of thoſe degrees.

in

in this experiment, red being the uppermoſt colour in the lower bow, and violet in the other.

The rainbow is not in the clouds, but in the falling rain, and always oppoſite the ſun. The different order of the colours in the bows ariſes from their different reflections; thoſe of the under bow being cauſed by two refractions and one reflection, and thoſe of the upper, by two refractions and two reflections, and therefore the colours of this are leſs bright than the other, their ſtrength being diminiſhed by every reflection.

Now, it has been proved by repeated experiments, that forty degrees forms the greateſt angle by which the moſt refrangible rays can, after one reflection, be refracted to the eye; and that ſomething more than forty-two degrees forms the greateſt angle, under which the leaſt refrangible rays can come to the eye after one

one reflection. Therefore all the colours of the lower bow muſt lie in the ſpace of leſs than two degrees. In like manner it has been proved, that fifty degrees make the leaſt angle under which the leaſt refrangible rays can be viſible to the eye after two reflections; and that about fifty-four degrees will be the leaſt angle under whichthe moſt refrangible rays can come to the eye after two reflections. Therefore all the colours of the upper bow muſt be in leſs than four degrees.

It follows from what is here ſaid, that all rainbows are of a circular form and equal magnitude, and as they are always oppoſite the ſun, the parts we ſee of them muſt be in proportion to his height above the horizon: when his altitude is forty degrees, only the upper rainbow can be viſible, and when it is fifty-four degrees there can be no rainbow: but as the ſun's height, during the winter half year, is never equal to forty degrees, there may then be always two bows viſible.

RECREATION XL.

The prifmatic camera obfcura.

MAKE two holes F, *f*, (Plate XIII. Fig. 5.) in the fhutter of a dark chamber, near to each other, and againft each hole place a prifm A B C, and *abc*, in a perpendicular direction, that their fpectrums M N may be caft on the paper in a horizontal line, and coincide with each other; the red and violet of the one being in the fame part with thofe of the other. The paper fhould be placed at fuch a diftance from the prifms that the fpectrum may be fufficiently dilated.

Provide feveral papers nearly of the fame dimenfion with the fpectrum, crofs thefe papers, and draw lines parallel to the divifions of the colours. In thefe divifions cut out fuch figures as you fhall find will have an agreeable effect, as flowers, trees, animals, &c.

When

When you have placed one of thefe papers in its proper pofition, hang a black cloth or paper behind it, that none of the rays that pafs through may be reflected, and confufe the phenomenon. The figures cut on the paper will then appear ftrongly illuminated with all the original colours of nature.

If while one of the prifms remains at reft, the other be revolved on its axis, the continual alteration of the colours will afford a pleafing variety; which may be farther increafed by turning the prifm round in different directions.

When the prifms are fo placed that the two fpectrums become coincident in an inverted order of their colours, the red end of one falling on the violet end of the other, if they be then viewed through a third prifm DH, held parallel to their length, they will no longer appear coincident, but in the form of two diftinct fpectrums,

ſpectrums, *p t* and *n m*, (Fig. 6.) croſſing one another in the middle, like the letter X. The red of one ſpectrum and the violet of the other, which were coincident at NM, being parted from each other by a greater refraction of the violet to *p* and *m*, than that of the red to *n* and t.

This Recreation may be farther diverſified by adding two other priſms, that ſhall form a ſpectrum in the ſame line, and contiguous to the other; by which not only the variety of figures, but the viciſſitude of colours will be conſiderably augmented.

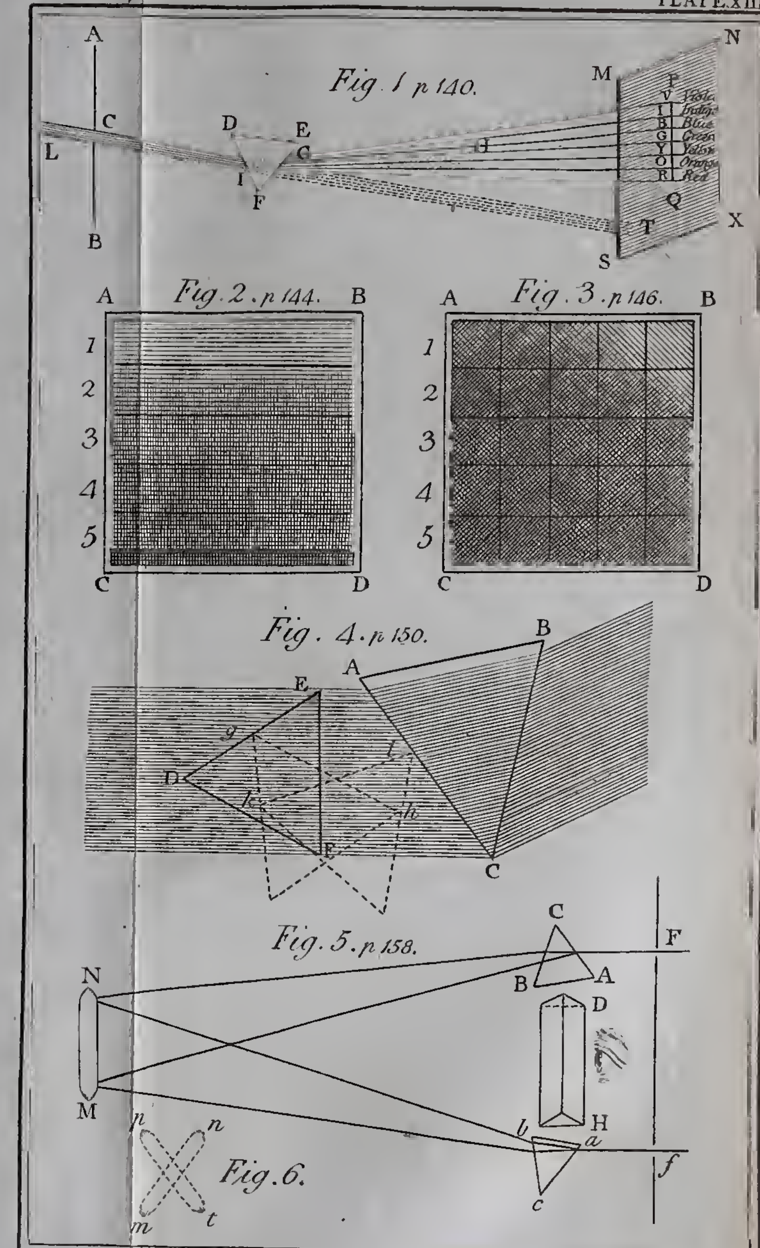
RECREATION XLI.

The diatonic ſcale of colours.

THE illuſtrious Newton, in the courſe of his ſagacious inveſtigations of the properties of light, diſcovered that the length of the ſpaces which the ſeven primary colours poſſeſs in the ſpectrum, exactly correſponds to thoſe of chords

that

Vol. II. p 160. PLATE. XIII.



J. Lodge Sculp

that found the seven notes in the diatonic scale of music. As is evident by the following experiment.

On a paper in a dark chamber let a ray of light be largely refracted into the spectrum AFTMGP, (Plate XIV. Fig. 1.) and mark the precise boundaries of the several colours, as *a*, *b*, *c*, &c. Draw lines from those points perpendicular to the opposite side, and you will find that the spaces M *r f* F, by which the red is bounded; *q p d e*, by which the orange is bounded; *p o c d*, by which the yellow is bounded, &c. will be in exact proportion to the divisions of a musical chord for the notes of an octave, that is, as the intervals of these numbers, 1, $\frac{8}{9}$, $\frac{5}{6}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{9}{16}$, $\frac{1}{2}$.

RECREATION XLII.

Colorific music.

FATHER Caſtel, a Frenchman, in a curious book he has publiſhed on Chromatics, ſuppoſes the note *ut* to anſwer to blue in the priſmatic colours, the note *re* to yellow, and *mi* to red. The other tones he refers to the intermediate colours, from whence he conſtructs the following gamut of colorific muſic.

Ut	Blue
Ut ſharp	Sea-green
Re	Bright green
Re ſharp	Olive green
Mi	Yellow
Fa	Aurora
Fa ſharp	Orange
Sol	Red
Sol ſharp	Crimſon
La	Violet
La ſharp	Blue violet
Si	Sky Blue
Ut	Blue

This gamut, according to his plan, is to be continued in the ſame manner for the fol-

following octave; except that the colours are to be more vivid.

He supposes that these colours by striking the eye in the same succession as the sounds, to which he makes them analogous, do the ear, and in the same order of time, they will produce a correspondent sensation of pleasure in the mind. It is on these general principles, which F. Castel has ingeniously dilucidated in his treatise, that he has endeavoured, though with little success, to establish his ocular harpsichord.

The construction of this instrument, as here explained, will show that the effects produced by colours by no means answer those of sounds, and that the principle relation there is between them, consists in the duration of the time that they respectively affect the senses.

Between two circles of pasteboard, of ten inches diameter, AB and CD (Plate

XIV. Fig. 2.) encloſe a hollow paſteboard cylinder E, eighteen inches long. Divide this cylinder into ſpaces half an inch wide, by a ſpiral line that runs round it from top to bottom, and divide its ſurface into ſix equal parts by parallel lines drawn between its two extremities; as is expreſſed in the figure.

Let the circle A B, at top, be open, and let that at bottom, CD, be cloſed, and ſupported by an axis or ſcrew, of half an inch diameter, which muſt turn freely in a nut placed at the bottom of a box we ſhall preſently deſcribe. To the axis juſt mentioned adjuſt a wooden wheel G, of two inches and a half in diameter, and that has twelve or fifteen teeth, which take the endleſs ſcrew H. Let this cylinder be incloſed in a box I L M N (Fig. 3.) whoſe baſe is ſquare, and at whoſe bottom there is a nut, in which the axis F turns. Obſerve, that the endleſs ſcrew H, ſhould come out of the box, that it may receive the

the handle O, by which the cylinder is to be turned.

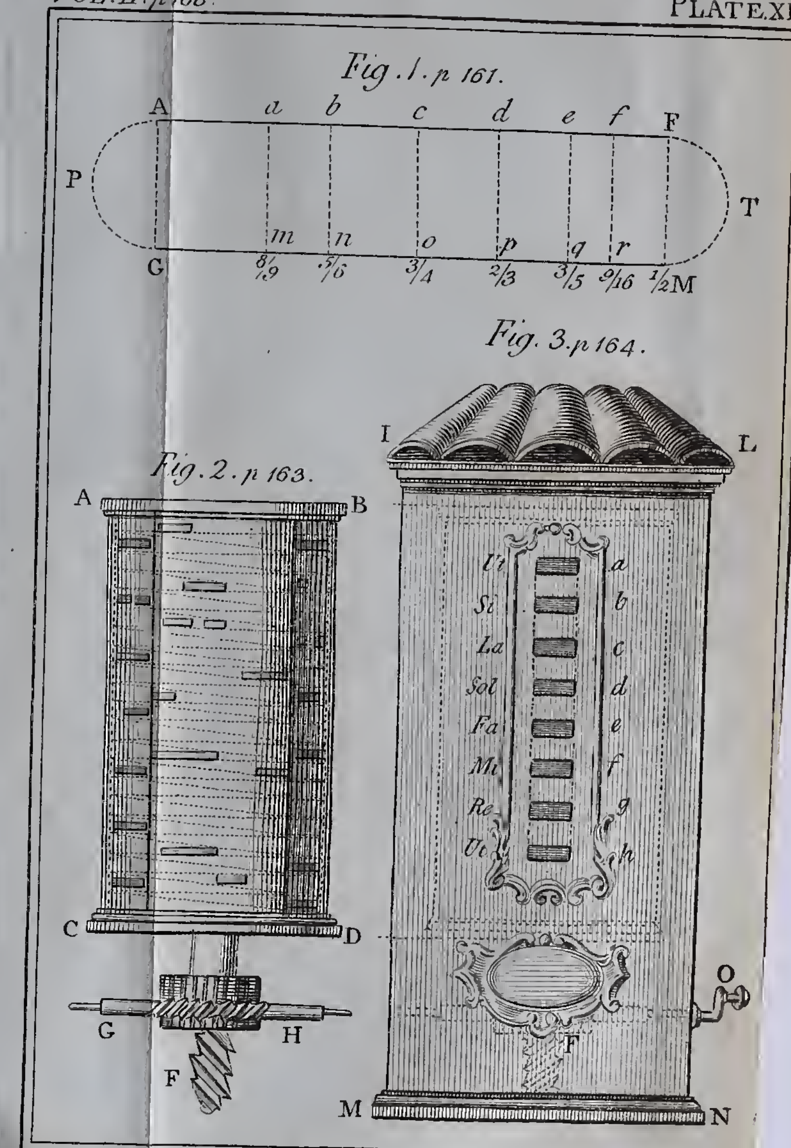
This box being clofed all round, place over it a tin covering, which muft be perforated in different parts; from this cover there muft hang three or four lights, fo placed that they may ftrongly illumine the infide of the cylinder. In one fide of this box (which fhould be covered with pafteboard) cut eight apertures of half an inch wide, and one-third of an inch high; they muft be directly over each other, and the diftance between them muft be exactly two inches. It is by thefe openings, which here correfpond to the mufical notes, that the various colours analogous to them, are to appear; and which being placed on the pafteboard cylinder, as we have fhown, are reflected by means of the lights placed within it.

It is eafy to conceive, than when the handle O is turned, the cylinder in con-

ſequence riſing half an inch, if it be turned five times round, it will ſucceſſively ſhow, at the openings made in the ſide of the box all thoſe that are in the cylinder itſelf, and which are ranged according to the direction of the inclined lines drawn on it. It is therefore according to the duration of the notes which are to be expreſſed, that the apertures on the cylinder are to be cut. Obſerve that the ſpace between two of the parallel lines drawn vertically on the cylinder, is equal to one meaſure of time, therefore for every turn of the cylinder, there are ſix meaſures, and thirty meaſures for the air that is to be played by this inſtrument.

The ſeveral apertures being made in the ſide of the cylinder, in conformity to the notes of the tune that is to be expreſſed, they are to be covered with double pieces of very thin paper, painted on both ſides with the colours that are to repreſent the muſical notes.

This



J. Lodge Sculp.

This Recreation might be executed in a different manner, and with a much greater extent; but as the entertainment would not equal the trouble and expence, we have thought it ſufficient to give the above piece, by which the reader will be enabled to judge how far the analogy ſuppoſed by F. Caſtel really exiſts.

This article is taken from M. Guyot, who, though he commends the good father's ingenuity and induſtry, attributes but little merit to his ſcheme. Not having ſeen F. Caſtel's book, we cannot pretend to judge of the merit of his plan. It is evident, however, from the foregoing Recreation, that there is a much ſtronger relation between ſounds and colours than M. Guyot ſeems to imagine.

PERSPECTIVE RECREATIONS.

If the following Recreations do not directly belong to optics, they have ſo great a reſemblance to it, that perhaps they could not be introduced any where elſe with ſo much propriety.

ANAMORPHOSES.

RECREATION XLIII.

To draw on a plane ſurface an irregular figure, which, when ſeen from a proper point of view, will appear exactly ſimilar to a given figure.

ON a paper or paſteboard draw the parallelogram ABCD (Pl. XV. Fig. 1.) of what ſize you pleaſe, provided the ſides A B and C D be longer than A C and BD; let it be, for example, four inches long and three wide. Divide it into twelve equal parts, and each of thoſe into four other

other equal parts*. On this parallelogram draw the regular figure that you would have reprefented, in a diftorted form, on the plane.

Draw on a paper the line BA (Fig. 2.) indefinite toward A. Directly over the point B, mark the point of view C, and let fall the perpendicular CB. On the line AB mark the point C, and draw from the point of view C, to that point D, the line CD. On the fame line, and at a convenient diftance from the point C, draw the line FG, of the fame length with AC (Fig. 1.) let it be perpendicular to the line CD, and by which it muft be bifected. From the point C to F and G, draw the two lines CF and CG, and continue them till they meet the line AB at the points H and O.

* The fmaller the divifions are, the more eafy it will be to reprefent the fubjects with precifion.

The

The line HO will then appear to the eye C of the ſame dimenſion with the line FG, which is equal to the width of the parallelogram ABCD, as muſt neceſſarily follow from the principle laid down in the part of Optics; that is, becauſe both theſe lines appear under the ſame angle HCO.

Then divide the line F G into the ſame number of parts with the ſide of the parallelogram A C, (Fig. 1.) and from the point of view C, to the line AB, draw the lines CI, CL, CM, CN, through the diviſions in the line FG.

On another paper draw the line A B (Fig. 3.) equal to the line C A, (Fig. 2.) and at its extremity B, erect the indefinite perpendicular BC. From the point B of the line AB to the point E, in the ſame line, ſet off a ſpace equal to the line C F, (Fig. 2.) At the point E, divide the line A B by the perpendicular H I, equal to C D,

CD, (Fig. 1.) that is, equal to the length of the parallelogram. This line muſt alſo be divided into two equal parts by the line AB.

From the point B to the points H and I, draw the lines BH and BI, and continue them towards C and D. Take the diſtances that are between H and I, LD, M and N, (Fig. 2.) and tranſpoſe them to the line AB (Fig. 3.) from A to I, L, M, N, O, and draw the lines Y, Z, perpendicular to each of theſe diviſions. Divide the line CD into eight equal parts, and draw the lines BG, BQ, BR, BS, BT, and BV.

Theſe diviſions being made, the trapezium CHDI will be divided into as many parts as the parallelogram ABCD, (Fig. 1.) and all theſe diviſions, though of themſelves irregular, will appear to the eye, when placed at the point C, (Fig. 2.) of the

ſame

ſame figure and magnitude as the parallelogram: all the lines that form the diviſions included in the trapezium CHDI being ſeen under ſimilar angles. In order to facilitate the tranſpoſing the ſeveral parts of the deſign contained in the parallelogram, to the trapezium, it will be proper to number the principal diviſions. The whole, moreover, ſhould be traced with great preciſion *. Obſerve, that all the right lines in the parallelogram form as many right lines in the trapezium, therefore when you have marked their extremities, you may draw them with a ruler from one point to the other. With regard to curve lines, you will judge of their direction by the points where they cut the diviſions of the parallelograms, and tranſ-

* This method of drawing an irregular figure is taken from M. Guyot, and differs from thoſe that are given by Niceron and Ozanam, as it appears more exact to place the deſign that is to be repreſented in ſuch manner that the ray, or principal point of view, may fall perpendicular on the center of the ſuppoſed picture placed at FG.

poſe

pofe them to the correfponding divifions of the trapezium.

Note, Care muft be taken that the paper on which the diftorted figure is drawn be well ftretched on a plane, that its furface mày be quite even. You fhould alfo examine it attentively fiom the point of view; and for that purpofe it will be convenient to have a little circle of brafs, through which a hole of about two tenths of an inch is made, and placed upon a ftand (fee Fig. 4.) By that overture this piece of perfpective illufion will produce an agreeable furprize.

Obferve that the diftance of the point of view from the picture may be taken at pleafure, provided it be not lefs than its width. When the point of view is near the picture it appears more deformed than when it is at a greater diftance, for the parts then become more extended toward CD; from whence it follows, that if we would

would execute a design of this sort on the side of a gallery, it must be regulated according to the dimensions of the part on which it is to be drawn. These subjects, when well executed, at full length, are highly agreeable, and appear the more extraordinary, as the eye not being able to view them but by parts, (when walking in the gallery*) we cannot form the least idea of what they will present when seen from a proper point of view, where the effect is truly admirable.

* There are, at the convent of Minims in the Palace Royale at Paris, several subjects of this kind, painted on the walls of the cloister by P. Niceron, who has published an excellent treatise on this art. Among others, the figure of a Magdalen daily excites the curiosity of a number of connoisseurs. Unfortunately, these pieces, which have suffered by time, have not been properly repaired.

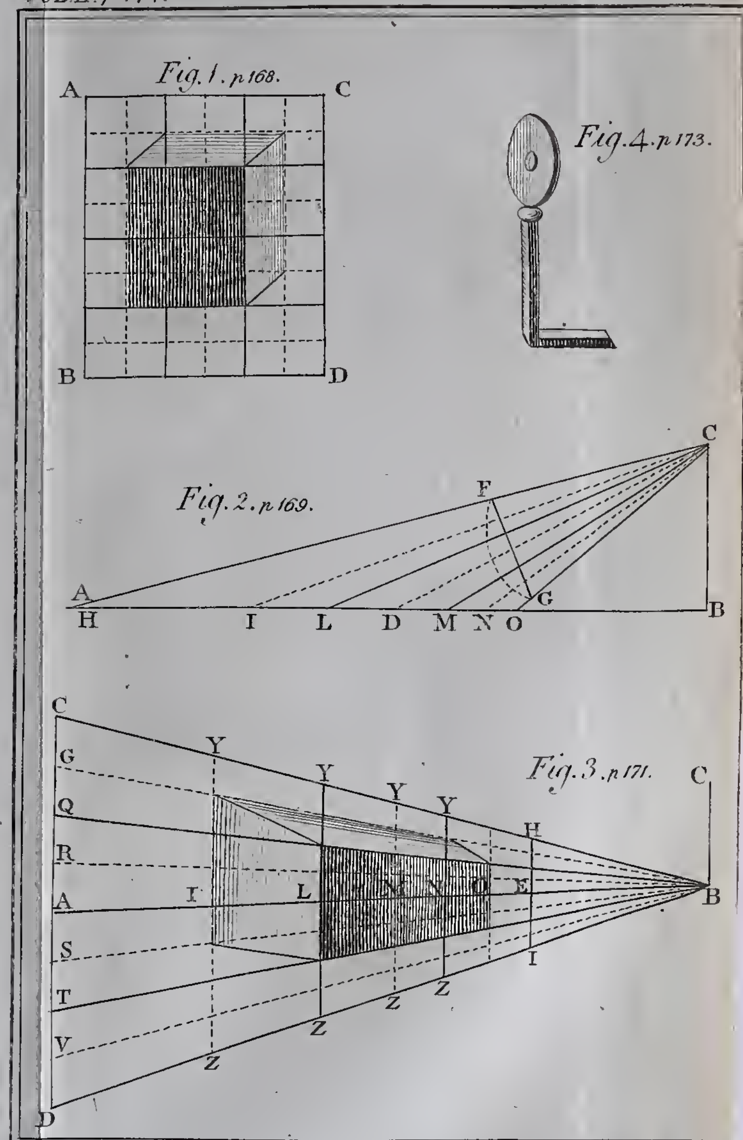


Fig. 1. p. 168.
A
C
B
D
Fig. 4. p. 173.
Fig. 2. p. 169.
C
F
A
H
I
L
D
M
N
O
G
B
C
G
Q
R
A
S
T
V
D
Y
Y
Y
Y
Fig. 3. p. 171.
C
H
I
L
M
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J. Lodge sc.

RECREATION XLIV.

To draw an irregular figure on a plane, which being ſeen from two oppoſite points of view, ſhall repreſent two different regular objects.

MAKE choice of a plane of convenient ſize, ſuppoſe two feet long and half a foot wide. Draw the line A B of the ſame length, (Plate XVI. Fig. 1.) continue it on each ſide to C and D, and erect the perpendiculars C F and D G to the height of about three inches. Draw the lines A F and B G, and divide the line A B into ſix equal parts at the points S, or into any other number you ſhall think fit. From the two points of view F and G draw the lines FS and GS, to thoſe ſix diviſions.

Then on the line G A ſet off the diſtance G B, and on the line F B the diſtance F A, and draw the two lines B H and A I, which will determine the width of the two ſubjects

jects you are to represent on the plane, and are to be viewed, the one from the point F, and the other from G; and of which the unequal divisions formed by the lines GS and FS, will determine those that are to correspond to the separate and inclined parts of the irregular figure which is to be seen from the points of view F and G.

This first preparation being made, draw the parallelogram ABCD (Fig. 2.) of the same length with the line AB in the preceding figure, and about six inches wide: divide it into two equal parts by the line FG, which continue to H and I, equal to the distance there is between CA and DB (Fig. 1.)

From the points AOSB (Fig. 1.) let fall the perpendiculars AA, OL, SL, and BC, on the line AC (Fig. 2.) and from the points L draw the lines LM parallel to AB.

From

From the four angles of the parallelogram ABCD, draw the lines A I and B I to the point of view I, and thoſe of C H and D H to the other point of view H; theſe lines will determine by the ſections at X and Y the apparent height of the figure.

Then divide the lines A B and C D, into as many equal parts as you ſhall think proper, and from thoſe points draw the lines N I and N H.

Next, draw on a paper the two parallelograms FGHI, LMNO, (Fig. 3.) and on them you are to draw the two different deſigns that you would repreſent in the diſtorted figure. Let each of theſe parallelograms be of an equal height with the diſtance X Y, (Fig. 2.) and of the ſame length as H B (Fig. 1.) Divide their height FH or LN, according to the diviſions of the line X Y (Fig. 2.) and their length H I or N O, according to thoſe of the line B H (Fig. 1.)

After having drawn the two deſigns, as correctly as poſſible, on the diviſions juſt mentioned, take a board or paſteboard ABCD (Fig. 4.) of the ſame dimenſions with the parallelogram ABCD, (Fig. 2.) and on it draw the lines LM, correſponding to the perpendiculars let fall from OS. (Fig. 1.) Theſe lines ſhould be drawn ſufficiently deep to admit the folds of paper hereafter mentioned.

Take a very thin paper ABCD (Fig. 5.) of about two feet and a half long, and ſix inches wide, and on it draw parallel lines, at diſtances correſponding to A O, O S, S O, &c. (Fig. 1.) which you will meaſure with a compaſs from the angles on the line A B (Fig. 1.)

Divide this paper into two equal parts by a line drawn from the points X and Y, and obſerve that it is on the ſpaces *b*, *b*, *b*, &c. that you are to draw the irregular figure which is to be ſeen from the point F; and

and on thofe of *c*, *c*, *c*, &c. that which is to be feen from the point G.

On each of thefe fpaces draw the lines, not punctuated, of the parallelogram ABCD (Fig. 2.) that terminate in the points H and I. Then trace on the fame paper all the ftrokes of the two figures drawn on the two parallelograms, (Fig. 3.) carefully obferving the feveral divifions to which they correfpond.

When this irregular figure is quite finifhed, fold the paper according to the divifions that have been drawn on it, fo that each of the divifions S, may turn one way, and each of the divifions O, the other way, and pafte the whole on a board, in fuch a manner that the folds made on the blank fide of the paper, may anfwer to the lines traced in the board. On the paper thus pafted lay fomething that may keep it in proper form till the pafte is dry. Then let it be fo placed that fix of its divifions

may be oppoſite to each of the points of view F and G.

To diſtinguiſh the objects on the parallelogram with greater preciſion, you muſt have (as in the foregoing Recreation) two little circles, with a ſmall hole in each, and place them exactly on the points of view that have been fixed. The eye being then placed at either of thoſe points, will diſcern the regular figure; but when the ſcheme is viewed in front, it preſents a form ſo diſtorted that it is impoſſible to conjecture what it is intended to repreſent.

Obſerve, This deſign differs in the conſtruction from that in the firſt Recreation; as here, the diviſions drawn on the irregular figure regulate thoſe of the two other figures. It is indeed more difficult, but then it is alſo more entertaining; and with a little application it may be eaſily executed, as nothing more is neceſſary than

to

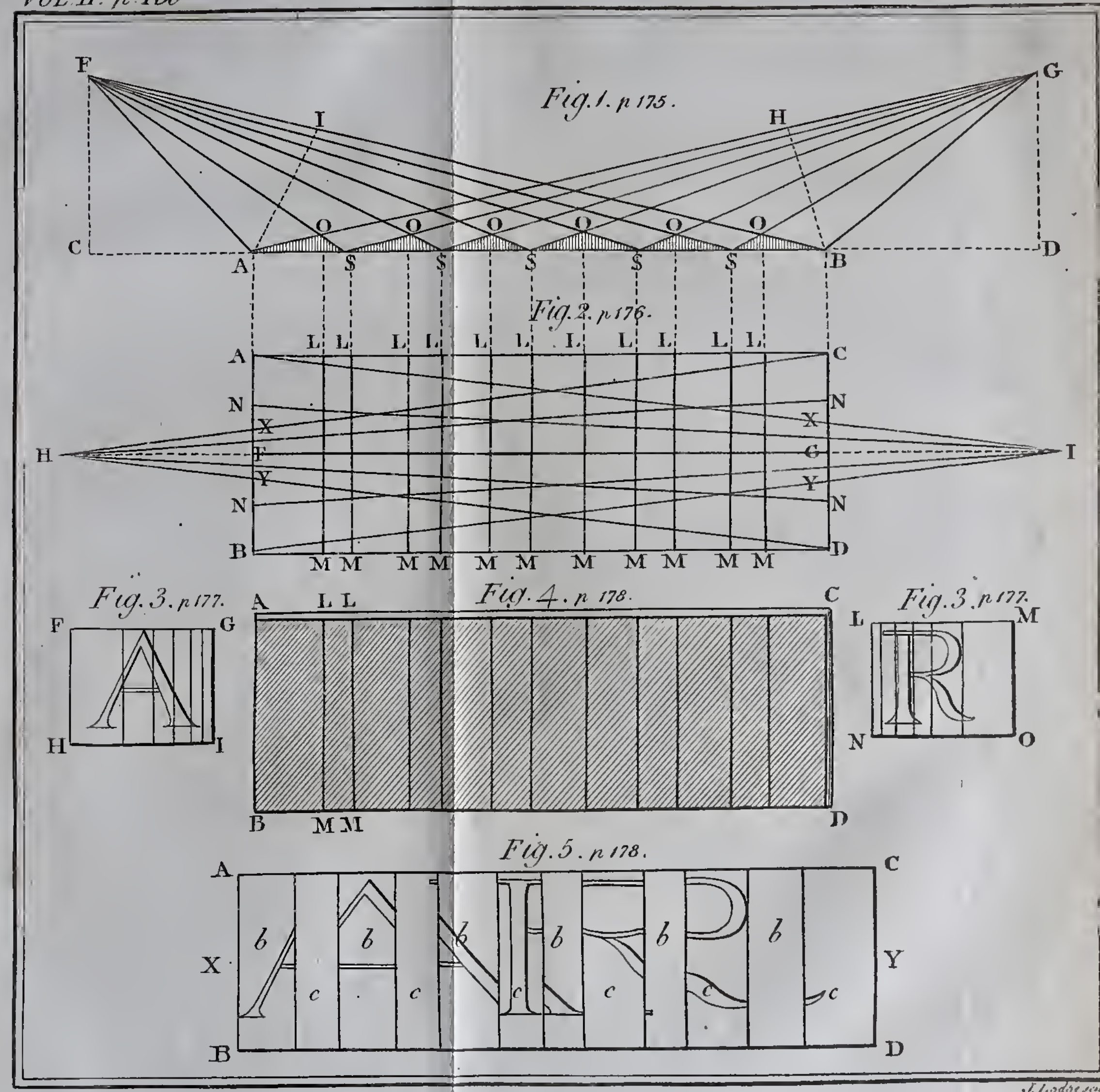


Fig. 1. p 175.
Fig. 2. p 176.
Fig. 3. p 177.
Fig. 4. p 178.
Fig. 3. p 177.
Fig. 5. p 178.
J. Lodge sculp

to transfer the divifions carefully from one figure to the other.

To perform this fort of anamorphofis with more celerity, you may draw the plan on a pafteboard, and placing a tranfparent paper over it, trace the fubject thereon ; the fame pafteboard will ferve to execute, equally well all forts of fubjects.

RECREATION XLV.

To draw on the bafe of a cone, an irregular figure, which fhall appear, when feen from a proper point of view, not only regular, but elevated above the furface of the cone.

THE geometric method that might be here given for drawing the figure propofed, being extremely tedious and difficult, on account of the various curves that it is neceffary to draw on the bafe of the cone, we fhall here defcribe a more fimple method, by making ufe of a lamp. This method may likewife be ufed in the

 drawing

drawing diſtorted ſubjects on all irregular ſurfaces, whatever their figure may be.

Let E F G (Plate XVII. Fig 1.) be the cone, on the baſis of which a diſtorted figure is to be drawn, that being viewed from the point H, ſhall appear regular, and exactly reſembling that which is placed at N M. Place the cone in a circular overture made in the board ABCD, which ſhould be ſupported by four feet, that the point of the cone may not touch the table on which it ſtands. Fix at the end of the board an upright piece I, that is to hold a ſmall circle of braſs, through which is made a hole H, of two tenths of an inch in diameter, that ſerves for the point of view.

Prepare a lamp as A, (Fig. 2.) the light of which may be raiſed or lowered at pleaſure, and to which is fixed a braſs arm BC, bearing a ſort of funnel D, in the ſhape of a truncated cone, and whoſe opening

ing at the end next the light is not more than three or four tenths of an inch in diameter.

Draw the ſubject you would repreſent on the baſe of the cone, on a piece of glaſs of equal height with the ſpace MN*, that is of the apparent height of the diameter E F, of the baſe of the cone when ſeen from the point H; place it perpendicular on the board at the point F, that is, at the extremity of the cone.

Theſe preparations being made, take away the piece that bears the point of view H, and place the lamp, ſo prepared in ſuch manner that the light may be exactly where the point H was. Its rays then paſſing through the glaſs at MN, will en-

* It muſt be drawn with a very light ſtroke, and you muſt make uſe of a colour that is quite opaque.

lighten all the lower ſurface of the cone, and there ſhow, in a diſtorted form, the ſubject that is painted on the glaſs.

Then draw with a pencil all the ſtrokes of the ſhadow that are on the cone; and taking away the light, place the point of view H, and ſee if what you have drawn correſpond with the ſubject on the glaſs, correcting what imperfections there may chance to be. In the laſt place, colour the ſubject ſo traced on the cone, with the utmoſt attention, inſpecting your work from time to time from the point of view, before you give it the finiſhing ſtrokes.

When the figure that is drawn and painted on the baſe of the cone is viewed from the point H, it appears to be at the ſame point where the glaſs M N was placed, and in the ſame form that it was painted on that glaſs. The eye even perceives it above the ſurface of the board in which the cone is placed, and

and thereby receives a remarkable and pleafing illufion.

Note. This manner of drawing diftorted figures by means of a lamp and tranfparent glafs, may be advantageoufly ufed for all irregular figures, that are difficult to draw geometrically. The fubjects that are drawn on the glafs may alfo be fhaded and coloured, in the fame manner as for the camera obfcura; in order to have the appearance of colours on the diftorted picture.

If a circle be defcribed on paper or pafteboard, and placed firm upon the table, where the cone is fuppofed to be, it will have precifely the fame effect.

RECREATION XLVI.

To draw, eaſily and correctly, a landſcape or any other object, without being obliged to obſerve the rules of perſpective, and without the aid of the camera obſcura.

PROCURE a box of paſteboard ABCD (Plate XVII. Fig. 3.) of about a foot and a half long, and made in the ſhape of a truncated pyramid, whoſe baſe BDFG is eight inches wide, and ſix inches high. Fix to the other end of it a tube of four or five inches long, and which you can draw out from the box more or leſs. Line the inſide of the box with black paper, and place it upon a leg or ſtand of wood H, and on which it may be elevated or depreſſed by the hinge I.

Take a ſmall frame of wood A B C D (Fig. 4.) and divide it at every inch by lines of black ſilk drawn croſs it, forming forty-eight

eight equal parts; divide theſe into ſtill ſmaller equal parts, by lines of finer ſilk*: fix this frame at the end B D, as the baſe of the pyramid.

Provide a drawing paper, divided into the ſame number of parts as is the frame, by lines lightly drawn in chalk. It is not material of what ſize theſe diviſions are; that will depend entirely on the ſize you propoſe to draw the objects by this inſtrument.

Place this inſtrument oppoſite a landſcape, or any other object that you want to draw, and fix the leg firmly on, or in the ground, that it may not ſhake: then turning it to the ſide you chooſe, raiſe or incline it, and put the tube farther in or out, till you have gained an advantageous view of the object you intend to draw.

* The different ſize of the ſilk ſerves to diſtinguiſh more readily the correſponding diviſions.

Place

Place yourſelf by the inſtrument*, which you have adjuſted to the height of your eye, and looking through the tube, carefully obſerve all that is contained in each diviſion of the frame, and tranſpoſe it to the correſponding diviſion in your paper: and if you have the leaſt knowledge in painting, or even drawing, you will make a very pleaſing picture, and one in which all the objects will appear in the moſt exact proportion.

Note. By the ſame method you may draw all ſorts of objects, as architecture, views, &c. and even human figures, if they remain ſome time in the ſame attitude, and are at a proper diſtance from the inſtrument.

* You may provide yourſelf with one of thoſe ſtools that fold up, and are eaſily portable.

RECRE-

RECREATION XLVII.

Illuminated profpects.

PROVIDE yourfelf with fome of thofe prints that are commonly ufed in optical machines, printed on very white and very thin paper; taking care to make choice of fuch as have the greateft effect from the manner in which the objects are placed in perfpective. Pafte one of thefe on the borders of a frame, and paint it carefully with the moft lively colours, making ufe of none that are terreftrial. Obferve to retouch thofe parts feveral times where the engraving is ftrongeft *, then cut off the upper part or fky, and fix that on another frame.

The prints being thus prepared, place them in a box ABCD (Plate XVII. Fig. 5.)

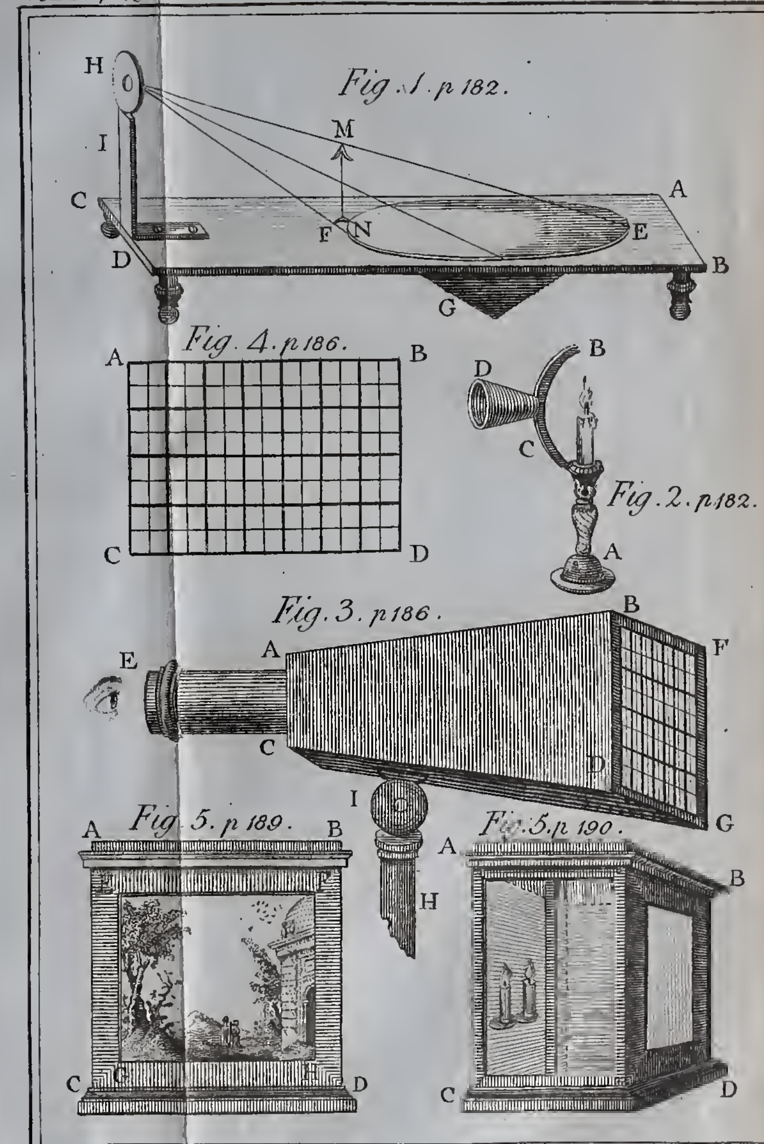
* When you colour a print, place it againft a plate of glafs, in an erect pofition before you, that it may be enlightened by the fun. You may alfo colour both fides of the print.

the

the opening to which E F G H, ſhould be a little leſs than the print. Cover this opening with a glaſs, and paint all the ſpace between it and the prints, which ſhould be about two or three inches, black. The frame that contains the ſky ſhould be about an inch behind the other. In the back part of this box, which is behind the prints, and which may be about four inches deep, place four or five ſmall candleſticks to hold wax lights, and cover that part entirely with tin, that it may be the more luminous.

When the print is placed between the wax lights and the opening in the front of the box, and there is no other light in the room, the effect will be highly pleaſing; eſpecially if the lights are at a ſufficient diſtance from each other, and not too ſtrong, that they may not occaſion any blots in the print. Thoſe prints that repreſent the riſing or ſetting of the ſun will have a very pictureſque appearance.

Such



J. Lodge Sculp

Such as reprefent conflagrations have alfo a ftriking effect.

Note. There fhould be two grooves for the print next the glafs, that you may infert a fecond fubject before you draw away the firft: and that the lights in the back of the box may not be difcovered.

You muft not, thinking to make the print more tranfparent, cover it with varnifh: for that will prevent the degradation of the colours from being vifible. The frame fhould enter the fide of the box by a groove, that a variety of fubjects may be introduced.

RECREATION XLVIII.

Tranfparent illuminations.

THE box that is to enclofe thefe fubjects may be made in the fame manner with that of the preceding Recreation, only obferving that it will be proper to augment

ment the number of lights, and employ ſuch prints as are agreeable to the ſubject.

With a very ſmall circular tool you are to cut out all the places where the light is intended to appear, or where it is expreſſed, if the print repreſent an illumination. Particular care muſt be had to make uſe of the fineſt tools in thoſe parts of the print that are intended to appear at the greateſt diſtance.

Theſe prints muſt by no means be tranſparent, like thoſe in the preceding Recreation; on the contrary, they ſhould be printed on a thick paper, or rather it ſhould be doubled, that very little of the engraving may appear. Behind the print muſt be placed a very fine tranſparent paper, varniſhed, fixed on a frame, and lightly painted with a deep yellow, or ſaffron colour, which muſt be laid on thickeſt at thoſe places that are oppoſite the parts of the print that are to appear at the greateſt diſtance.

The

The ſetting of the ſun, ſucceeded by a night ſcene, may be very pleaſingly repreſented in this method. Thus: procure a landſcape, in which is the figure of the ſetting ſun, illuminated as above deſcribed. Let the bottom of this ſcene reſt upon an upright board in the box, of about two or three inches high, and let it be gradually moved off that board, and lowered down to the bottom of the box, on the ſide next the glaſs, by which means the ſun will appear to deſcend. Let the lights then be gradually withdrawn: and change the firſt landſcape for a night ſcene, with the moon and ſtars, properly perforated. The yellow paper muſt be changed for one that is white and tranſparent, and the lights be again introduced, when the moon, ſtars, and other illuminated parts will appear in their natural form. For the more caſy removing of the lights they may be all placed upon one ſtand, but at different diſtances.

This piece of illumination might alſo be put into the common optical machine; but the magnifying glaſs there uſed conſiderably enlarging the object, the light reflected by the cut and tranſparent parts, then becomes greatly weakened, as it takes up a much larger ſpace; and that greatly diminiſhes the vivacity which is neceſſary to imitate nature, and to produce the illuſion. If, however, you are deſirous of viewing this piece by the magnifier, you muſt take away the inclined mirror which is placed in thoſe ſort of optical machines, and place the tranſparent picture or print in the front of the glaſs; or otherwiſe it will be ſcarce poſſible to render it luminous, except by reflection, which affords but a very feeble light.

ACOUSTICS.

THE ſcience of acouſtics inſtructs us in the nature of ſound. It is divided by ſome writers into diacouſtics, which explains the properties of thoſe ſounds that come directly from the ſonorous body to the ear; and catacouſtics, which treats of reflected ſounds: but ſuch diſtinction does not appear to be of any real utility.

DEFINITIONS.

1. Sounds are either acute or grave, ſimple or compound.

2. Thoſe ſounds that are ſhrill or ſharp are called acute: and

3. Thoſe that are deep or hollow, are called grave ſounds.

4. A ſimple ſound is that produced by a ſingle ſtroke on a ſonorous body; and compound ſounds are thoſe that proceed from ſeveral bodies ſtruck at the ſame time, or from ſeveral ſtrokes on different parts of the ſame body.

5. A chord is a ſtring of catgut, braſs wire, &c. ſo ſtretched as when ſtruck to yield a diſtinct ſound.

6. A vibration is the regular, alternate motion of bodies, by which, when put out of their natural ſtate, they endeavour to return to it. Thus the ſtring AB (Pl. XVIII. Fig. 1. being forced out of its natural poſition to that of A *c* B, vibrates to *d*, and then to *e*, *f*, *g*, &c. till it returns to its firſt ſtate at A B.

APHORISMS.

1. All ſound is produced by an undulatory or wave-like motion of the air*, excited by the vibrations of a ſonorous body proceeding from a ſtroke of ſome other body.

2. Acute ſounds ariſe from quick vibra-

* That air is the medium of ſound is evident from a bell placed in the receiver of an air-pump, which may be heard to a conſiderable diſtance before the air is exhauſted, but after can ſcarce be diſtinguiſhed when quite near.

tions

tions of the parts of a body, and grave ſounds from ſlow vibrations.

3. Smooth and clear ſounds proceed from bodies that are homogeneous, and of an uniform figure; and harſh or obtuſe ſounds, from ſuch as are of a mixed matter and irregular figure.

4. In bodies of a ſimilar figure and dimenſion, and of equal elaſticity, their tones are equal to their denſities: the denſer the body the graver is the tone; therefore a bar of gold muſt have a graver ſound than one of ſilver, of equal dimenſions; ſuppoſing them to be of equal elaſticity.

5. If two bodies are compoſed of the ſame matter, and are of ſimilar figure, their tones will be in proportion to the quantities of matter. Thus, the tones of two globes of braſs will be to each other in proportion to their diameters.

6. The vibrations of chords is in proportion to their lengths, diameters, and tenſion.

7. All the vibrations of the ſame chord, as A *c* B, (Plate XVIII. Fig. 1.) A *d* B, A *e* B, &c. are made in the ſame time.

8. if two chords are of the ſame diameter or thickneſs, and equally ſtretched, their vibrations, in the ſame time, will be in proportion to their lengths inverſely, that is, a chord of ſix inches will make two vibrations while a chord of twelve inches makes one*.

9. If two chords frequently vibrate together they produce a concord; and the more frequent the coincidence of vibration, the more pleaſing the concord.

* From hence we learn how to divide any chord ſo that it may ſound the ſeven concords: as thus, divide the line A B (Plate XVIII. Fig. 2.) into two equal parts in C, and CB into two equal parts at D, and C D into two equal parts at E. Then AC will be to AB as $\frac{1}{2}$ that is, an octave; A C to A D as $\frac{2}{3}$, a fifth; A D to AB as $\frac{3}{4}$, a fourth; AC to AE as $\frac{4}{5}$, a third greater; A E to A D as $\frac{5}{6}$, a third leſſer; E B to A E as $\frac{3}{5}$, a ſixth greater; and A E to A B as $\frac{5}{8}$, a ſixth leſſer.

10 Sound

10. Sound is propagated in concentric circles every way round the fonorous body*.

11. All founds, whether great or fmall, are of equal velocity.

12. The fpace paffed over by found is conftantly equal in equal times, whether it come from a greater or lefs diftance.

13. The motion of found is at the rate of 1142 feet in a fecond, and no obftacles obftruct its progrefs; a contrary wind only a fmall matter diminifhing its velocity†.

* The diftance to which founds may be heard is very great. Authors of credit relate that the found of cannon has been heard 180 and 200 miles.

† By this axiom we are enabled to find the diftance between the objects that would be otherwife immeafurable. For example, fuppofe you fee the flafh of a gun in the night at fea, and tell feven feconds before you hear the report, it follows therefore, that the diftance is feven times 1142 feet; that is twenty-four yards more than a mile and a half. In like manner if you obferve the number of feconds between the lightning and the report of the thunder, you know the diftance of the cloud from whence it proceeds.

14. The velocity of ſound is to that of a briſk wind as fifty to one.

15. The ſtrength of ſounds is greateſt in cold and denſe air, and leaſt in that which is warm and rarefied.

16. In all ſounds the angle of incidence is equal to that of reflection, that is, if a line be drawn perpendicular to the reflecting ſurface, the point from which the ſound iſſues, and that to which it is reflected, will be equally diſtant from the perpendicular line.

RECREATION XLIX.

The Æolipiles.

AN æolipile is a fmall globe of brafs or other metal, into which a flender neck or pipe is inferted. This ball, when made red hot, is caft into a veffel of water, which will rufh into its cavity, then almoft void of air. The ball being then fet on the fire, the water, by the rarefaction of the internal air, will be forced out in fteam, by fits, with great violence, and with a ftrange noife.

If to the necks of two or more of thefe æolipiles there be fitted thofe calls that are ufed by fowlers and hunters, and the æolipiles be then placed privately on the fire; as the fteam rufhes forth they will make fuch a horrible noife, that a perfon who is ignorant of the contrivance cannot fail being greatly aftonifhed.

Great

Great care ſhould be taken that the neck of the æolipile be not ſtopped when it is placed on the fire, for in that caſe it would burſt, and might do no ſmall miſchief.

RECREATION L.

The communicative buſts.

LET there be two heads of plaſter of Paris, placed on pedeſtals, on the oppoſite ſides of a room. There muſt be a tin tube of an inch diameter, that muſt paſs from the ear of one head, through the pedeſtal, under the floor, and go up to the mouth of the other. Obſerve, that the end of the tube which is next the ear of the one head, ſhould be conſiderably larger than that end which comes to the mouth of the other. Let the whole be ſo diſpoſed that there may not be the leaſt ſuſpicion of a communication.

Now, when a perſon ſpeaks, quite low, into the ear of one buſt, the ſound is reverber-

verberated through the length of the tube, and will be diſtinctly heard by any one who ſhall place his ear to the mouth of the other. It is not neceſſary that the tube ſhould come to the lips of the buſt. If there be two tubes, one going to the ear, and the other to the mouth of each head, two perſons may converſe together, by applying their mouth and ear reciprocally to the mouth and ear of the buſts; and at the ſame time other perſons that ſtand in the middle of the chamber, between the heads, will not hear any part of their converſation.

RECREATION LI.

The oracular head.

PLACE a buſt on a pedeſtal in the corner of a room, and let there be two tubes, as in the foregoing Recreation, one of which muſt go from the mouth and the other from the ear of the buſt, through the pedeſtal, and the floor, to an under a-

partment.

partment. There may be likewiſe wires that go from the under jaw, and the eyes of the buſt, by which they may be eaſily moved.

A perſon being placed in the under room, and at a ſignal given applying his ear to one of the tubes, will hear any queſtion that is aſked; and immediately reply, moving at the ſame time the mouth and the eyes of the buſt, by means of the wires.

RECREATION LII.

A ſolar ſonata.

IN a large caſe, ſuch as is uſed for dials and ſpring clocks, the front of which, or at leaſt the lower part of it, muſt be of glaſs, covered on the inſide with gauze, let there be placed a barrel organ, which, when wound up, is prevented from playing, by a catch that takes a toothed wheel at the end of the barrel. To one end of this

this catch there muſt be joined a wire, at the end of which there is a flat circle of cork, of the ſame dimenſion with the inſide of a glaſs tube, in which it is to riſe and fall. This tube muſt communicate with a reſervoir that goes acroſs the front part of the bottom of the caſe, which is to be filled with ſpirits, ſuch as is uſed in thermometers, but not coloured, that it may be the better concealed by the gauze.

This caſe being placed in the ſun, the ſpirits will be rarefied by the heat, and riſing in the tube, will lift up the catch or trigger, and ſet the organ in play; which it will contine to do as long as it is kept in the ſun; for the ſpirits cannot run out of the tube, that part of the catch to which the circle is fixed being prevented from riſing beyond a certain point, by a check placed over it. Care muſt be taken to remove the machine out of the ſun before the organ runs down, that its ſtopping may be evidently effected by the cold.

When

When the machine is placed againſt the ſide of a room on which the ſun ſhines ſtrong, it may conſtantly remain in the ſame place, if you incloſe it in a ſecond caſe, made of thick wood, and placed at a little diſtance from the other. When you want it to perform, it will be only neceſſary to throw open the door of the outer caſe, and expoſe it to the ſun.

But if the machine be moveable, it will perform in all ſeaſons by being placed before the fire; and in the winter it will more readily ſtop when removed into the cold.

A machine of this ſort is ſaid to have been invented by Cornelius Dreble, in the laſt century. What the conſtruction of that was we know not; but might very likely be more complex, but could ſcarce anſwer the intention more readily.

RECRE-

RECREATION LIII.

An automatous harpſichord.

UNDER the keys of a common harpſichord let there be fixed a barrel, ſomething like that in a chamber organ, with ſtops or pins correſponding to the tunes you would have it play. Theſe ſtops muſt be moveable, ſo that the tunes may be varied at pleaſure. From each of the keys let there go a wire perpendicular down; the ends of theſe wires muſt be turned up for about one-fourth of an inch. Behind theſe wires let there be an iron bar, to prevent them from going too far back. Now, as the barrel turns round, its pins take the ends of the wires, which pull down the keys, and play the harpſichord. The barrel and wires are to be all encloſed in a caſe.

In the chimney of the ſame room where the harpſichord ſtands, or at leaſt in one adjacent,

adjacent, there muſt be a ſmoke jack, from whence comes down a wire, or cord, that, paſſing behind the wainſcot adjoining the chimney, goes under the floor, and up one of the legs of the harpſichord into the caſe, and round a ſmall wheel fixed on the axis of that firſt mentioned. There ſhould be pullies at different diſtances, behind the wainſcot and under the floor, to facilitate the motion of the chord.

This machinery may be applied to any other keyed inſtrument, as well as to chimes, and to many other purpoſes where a regular continued motion is required.

An inſtrument of this ſort may be conſidered as a perpetual motion, according to the common acceptation of the term, for it will never ceaſe going till the fire be extinguiſhed, or ſome parts of the machinery be worn out.

RECREATION LIV.

A ventoſal ſymphony.

AT the top of a ſummer-houſe, or other building, freely expoſed to the wind, let there be fixed the wings, or compounded vane AB (Pl. XVIII. Fig. 3.) on which is the pinion C, that takes the toothed wheel D, fixed on the axis E F, which at its other end carries the wheel G, that takes the pinion H. All theſe wheels and pinions are to be between the roof and the ceiling of the building. The pinion H is fixed to the perpendicular axis I K, which goes down very near the wall of the room, and may be covered after the ſame manner as are bell wires. At the lower end of the axis I K there is a ſmall pinion L, that takes the wheel M, fixed on the axis of the great wheel N O. In this wheel there muſt be placcd a number of ſtops, correſponding to the tunes it is to play. Theſe ſtops are to be moveable that the tunes may be altered at pleaſure. Againſt this

wheel there muſt hang twelve ſmall bells, anſwering to the notes of the gamut. Therefore, as the wheel turns round, the ſtops ſtriking againſt the bells, play the ſeveral tunes. There ſhould be a fly to the great wheel, to regulate its motion when the wind is ſtrong. The wheel N O, and the bells are to be encloſed in a caſe.

There may be ſeveral ſets of bells, one of which may anſwer to the tenor, another to the treble, and a third to the baſe; or they may play different tunes, according to the ſize of the wheel. As the bells are ſmall, if they are ſilver, their tone will be the more pleaſing.

Inſtead of bells, glaſſes may be here uſed, ſo diſpoſed as to move freely at the ſtroke of the ſtops. This machinery may likewiſe be applied to a barrel-organ; and to many other uſes.

RECRE-

RECREATION LV.

The nocturnal reveilleur.

AGAINST the wall of a room, near the cieling, fix a wheel of 12 or 18 inches diameter ; on the rim of which place a number of bells in tune, and, if you pleafe, of different fizes. To the axis of this wheel there fhould be fixed a fly to regulate its motion ; and round the circumference there muft be wound a rope, to the end of which is hung a weight.

Near to the wheel let a ftand be fixed, on which is an upright piece that holds a balance or moveable lever, on one end of which refts the weight juft mentioned, and to the other end muft hang an inverted hollow cone, or funnel, the aperture of which is very fmall. This cone muft be graduated on the infide, that the fand put

in may anſwer to the number of hours it is to run. Againſt the upright piece, on the ſide next the cone, there muſt be fixed a check, to prevent it from deſcending. This ſtand, together with the wheel, may be encloſed in a caſe, and ſo contrived as to be moved from one room to another with very little trouble.

It is evident from the conſtruction of this machine, that when a certain quantity of the ſand is run out, the weight will deſcend, and put the wheel in motion, which motion will continue till the weight comes to the ground. If the wheel be required to continue longer in motion, two or more pullies may be added, over which the rope may run.

The ſize of the bells ſhould be adapted to the ſomniferous diſpoſition of the party they are intended to rouze: or if you pleaſe, a drum or tabor may be added,

the

the ſtick to which may be fixed in the ſide of the room, by a ſwivel that goes through the middle of it ; and one end of it being lifted up by teeth placed on the circumference of the wheel, the other end will alternately ſtrike the drum.

RECREATION LVI.

A muſical caſcade.

WHERE there is a natural caſcade, near the lower ſtream, but not in it, let there be placed a large wheel, equal to the breadth of the caſcade: the diameter of this wheel, for about a foot from each end, muſt be much leſs than that of the middle part; and all the water from the caſcade muſt be made to fall on the ends*. The remaining part of the wheel which is to be kept free from the water, muſt conſiſt of bars, on which are placed ſtops that ſtrike againſt the bells, as in the 54th recreation: theſe ſtops muſt likewiſe be moveable, but larger than in that Recreation, as well as the bells, that they may be heard much farther. It is evident

* The water that falls on the wheel may paſs thro' pipes, ſo that part of it may be made occaſionally to paſs ever or fall ſhort of the wheel, as you would have the time of the muſic quicker or ſlower.

from

from the conftruction of this machine, that the water falling on the floats at the ends of the wheel, will make the ftops, which are adapted to different tunes, ftrike the notes of thofe tunes on the refpective bells. Two or three fets of bells may here be placed on the fame line, when the cafcade is fufficiently wide.

Where there is not a natural cafcade, one may be artificially conftructed, by raifing part of the ground, wherever there is a defcent of water; whether it be a ftream that fupplies a refervoir or fountain, or ferves domeftic ufes; or if it be refufe water that has already ferved fome other purpofe.

RECREATION LVII.

Reverberated ſounds.

SOUND, like light, after it has been reflected from ſeveral places, may be collected in one point, as in a focus; and it will be there more audible than in any other part, even than at the place from whence it proceeded. On this principle it is that a whiſpering gallery is conſtructed.

The form of this gallery muſt be that of a concave hemiſphere*, as ABC (Pl. XVIII. Fig. 4.) and if a low ſound or whiſper be uttered at A, the vibrations expanding themſelves every way will impinge on the points DDD, &c. and from thence be reflected to EEE, and from thence to the points F and G, till at laſt they all meet

* A cylindric or elliptic arch will anſwer ſtill better than one that is circular.

in

in C, where, as we have faid, the found will be the moft diftinctly heard.

Upon this principle alfo it is that the fpeaking trumpet is formed. For the found, in paffing through the long and narrow part of the tube, is continually reflected from its curved fide into the axis, and by that mean is prevented from fpreading till at its exit from the tube, whereby the ftrength of the found is greatly increafed.

As by the laft aphorifm, page 200, the angle of reflected found is equal to that of its incidence, if we know the point from which any found proceeds, and the place from which it is reflected, we may eafily find the point in which its echo will be heard.

To hear the echo of one fyllable, we muft be at the diftance of 120 feet from the reflecting furface: for two fyllables, 240 feet; for three fyllables 360 feet, &c.

For

For when we ſpeak diſtinctly we ſcarce pronounce more than three or three ſyllables and a half in a ſecond; and as by aphoriſm 13, ſound goes 1142 feet in a ſecond, if the diſtance between the ſpeaker and the reflecting ſurface were leſs than 360 feet, the firſt ſyllable would be returned before the laſt was pronounced *, and therefore the echo could not be diſtinctly heard. The echo in Woodſtock Park is ſaid to return 17 ſyllables in the day, and 20 in the night: for then the air being colder and denſer, by aphoriſm 15, the ſtrength of the ſound muſt be greater. From hence we may determine nearly, the diſtance of an object that is inacceſ-

* According to the aphoriſm, the diſtance ſhould be 380 feet; for the firſt ſyllable muſt go as far as is equal to the time the two laſt ſyllables are pronouncing, that is, two-thirds of a ſecond; therefore the diſtance ſhould be equal to two-thirds of 1142 feet, or $760\frac{2}{3}$, that is, $380\frac{1}{3}$ going and coming. But as ſome time muſt be allowed for the reflecting ſurface to be made to vibrate by the impinging ſound, the firſt diſtance, 360 feet, will be very near the truth.

ſible;

fible; for if an echo of 10 fyllables be reflected from the fide of a church or tower, it follows, from what has been faid, that the object muft be 1200 feet diftant.

The fame found may have feveral echoes, if there be feveral reflecting furfaces fo difpofed as to make it reverberate to the fame point. Thus a violin or other inftrument, when founded in a room where there are feveral arches of the fame form, will found like a number of violins of the fame fize playing in concert: or if the arches be of different forms, there will feem to be different inftruments playing the fame tune.

RECREATION LVIII.

The converſive ſtatue.

PLACE a concave mirror of about two feet diameter, as AB* (Plate XVIII. Fig. 5.) in a perpendicular direction. The focus of this mirror may be at 15 or 18 inches diſtance from its ſurface. At the diſtance of about five or ſix feet let there be a partition, in which there is an opening EF, equal to the ſize of the mirror; againſt this opening muſt be placed a picture, painted in water-colours, on a thin cloth, that the ſound may eaſily paſs through it†.

* Both the mirrors here uſed may be of tin or gilt paſteboard, this experiment not requiring ſuch as are very accurate.

† A Recreation of this kind may be performed in a field or garden, between two hedges, in one of which the mirror AB may be placed, and in the other an opening artfully contrived. The more effectually to conceal the cauſe of this illuſion,

Behind the partition, at the diſtance of two or three feet, place another mirror GH, of the ſame ſize as the former, and let it be diametrically oppoſite to it.

At the point C let there be placed the figure of a man ſeated on a pedeſtal, and let his ear be placed exactly in the focus of the firſt mirror; his lower jaw muſt be made to open by a wire, and ſhut by a ſpring; and there may be another wire to move the eyes; theſe wires muſt paſs through the figure, go under the floor, and come up behind the partition.

Let a perſon, properly inſtructed, be placed behind the partition near the mirror. You then propoſe to any one to ſpeak ſoftly to the ſtatute, by putting his

illuſion, the mirror AB may be fixed in the wainſcot, and a gauze, or any other thin covering, thrown over it, as that will not in the leaſt prevent the ſound from being reflected.

mouth

mouth to the ear of it, aſſuring him that it will anſwer inſtantly. You then give the ſignal to the perſon behind the partition, who, by placing his ear to the focus I, of the mirror GH, will hear diſtinctly what the other ſaid, and moving the jaw and eyes of the ſtatue, by the wires, will return an anſwer directly, which will, in like manner be diſtinctly heard by the firſt ſpeaker.

Remark. This Recreation appears to be taken from the Century of Inventions of the Marquis of Worceſter; one of thoſe men of ſublime genius, who are able to perform actions infinitely ſuperior to the capacity, or even the comprehenſion, of the mere ſcholar or man of buſineſs; and though his deſigns, at the time they were publiſhed, were treated with ridicule and neglect, by the great and little vulgar, who, judging by their own abilities, are ever ready to condemn what they cannot comprehend, yet

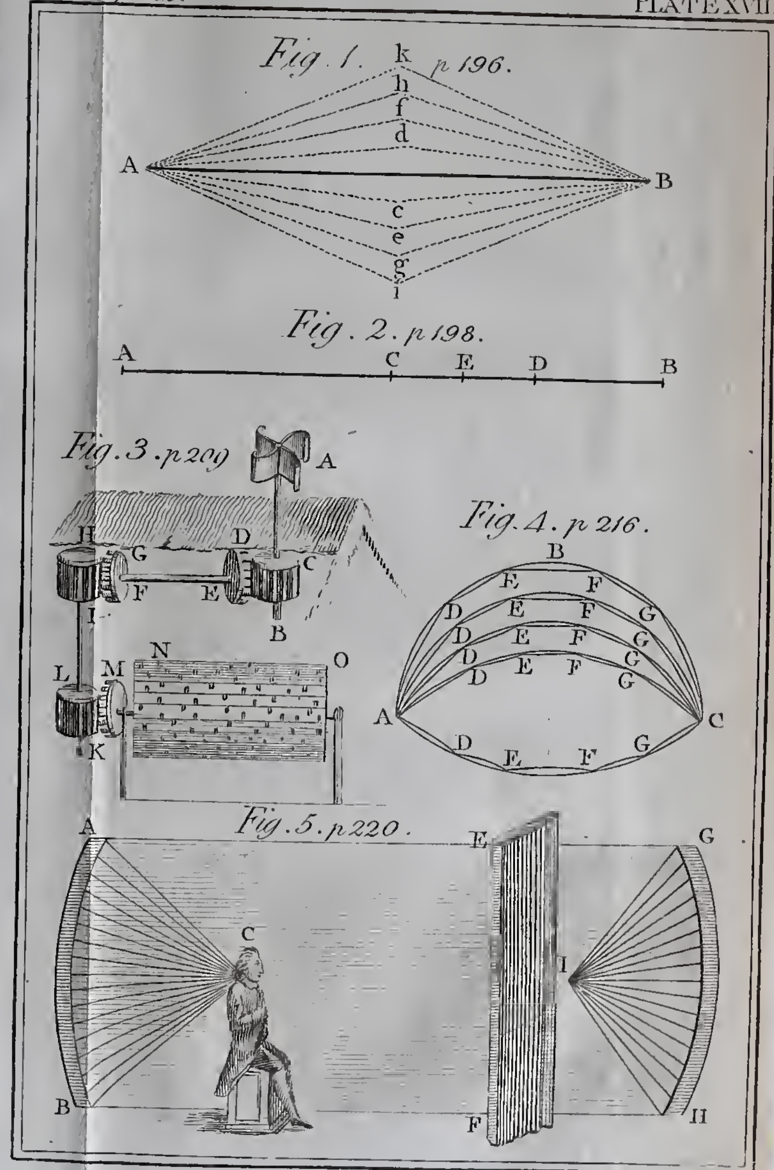


Fig. 1. p 196.
Fig. 2. p 198.
Fig. 3. p 209
Fig. 4. p 216.
Fig. 5. p 220.

yet they are now known to be generally, if not univerſally, practicable. The words of the Marquis are theſe: "How to make a brazen or ſtone head, in the midſt of a great field or garden, ſo artificial and natural, that, though a man ſpeak never ſo ſoftly, and even whiſper into the ear thereof, it will preſently open its mouth, and reſolve the queſtion in French, Latin, Welch, Iriſh, or Engliſh, in good terms, uttering it out of its mouth, and then ſhut it until the next queſtion be aſked."

RECREATION LIX.

The Organ.

THE recreation this inſtrument affords is known to every one; but what we here propoſe is a deſcription of the ſeveral parts of this moſt noble and comprehenſive of all muſical machines, and of the manner by which its numerous ſounds

are

are produced: and ſuch a deſcription will, perhaps, afford a perſon of an ingenious diſpoſition a recreation little inferior to the ſounds themſelves.

There are various ſorts of organs, but that we ſhall here deſcribe is the grand or church organ, which conſiſts of two parts, the main body, called the great organ, and the poſitive or little organ, which forms a ſmall caſe or buffet, commonly placed before the great organ. The ſize of an organ is generally expreſſed by the length of its largeſt pipe: thus they ſay, an organ of 8, 16, 32 feet, &c.*

The ſeveral parts of the church organ are as follows: HIH (Plate XIX. Fig. 1.) is the ſound-board, which is compoſed of two parts, the upper board or cover HHH,

* The organ in the cathedral church at Ulm, in Germany, is 93 feet high, and 28 broad: its largeſt pipe is 13 inches diameter, and it has 16 pair of bellows.

and

and the under board H I, which is much thicker than the other; each of thefe confifts of feveral planks laid with their edges to each other, and joined very clofe together. In the under fide of the lower board there are made feveral channels, which run in the direction L L, M M, &c. and are continued as far as there are ftops in the organ, and come almoft to the edge H K. Thefe channels are covered over, very clofe, with parchment or leather, all the way, except a hole that is commonly at the fore end next HK, upon which a valve or puff is placed. Thefe channels are called partitions. When this valve or flap is fhut it keeps out the air, and admits it when open. On the upper fide of the lower board there are likewife cut feveral broad, fquare channels, lying crofs the former, but not fo deep as to reach them; thefe lie in the direction L N, P Q, &c. To fit thefe channels there are the fame number of

wooden ſliders or regiſters *f*, *f*, *f*, &c. running the whole length; and theſe may be drawn out, or thruſt in, at pleaſure. The number of theſe is the ſame as that of the ſtops in the organ.

K K K is the wind-cheſt, which is a ſquare box, fitted cloſe to the under ſide of the lower board, and made air tight, ſo that no air can get out, but what goes through the valves, along the partitions.

V V are the valves or puffs, which open into the wind-cheſt; they are all incloſed in it, and may be placed in any part of it, as occaſion ſhall require. One of theſe valves, with the ſpring that ſhuts it and the wire that opens it, is repreſented by Fig. 2.

C, D, E, F, &c. are the keys on which the fingers are placed, when the organ is played: theſe keys lie over the horizontal

bar

bar of wood W, in which are ſtuck an equal number of wire pins *z z*, on which keys are fixed ; and the keys move up and down on the bar, as on a center. There is another bar, againſt which the keys fall when put down, and which is here marked 3: on this alſo are ſeveral wires which go through the keys, to guide them ; and on this bar a liſt is faſtened to hinder the keys from knocking againſt the wood.

The keys are made to communicate with the valves ſeveral ways as we ſhall now deſcribe. Firſt, *s*, *s*, *s*, are the key-rollers, moving on the pivots *t*, *t* : theſe rollers lie horizontally, one above another, and are of ſuch a length as to reach from the valve to the key : *a*, *a*, *a*, are arms or levers fixed to the key rollers : *w*, *w*, the valve wires fixed to the arms *a*, *a*, and to the valves V, and go through the holes *h*, *h*, in the bottom of the wind cheſt : *b b b*,

are likewiſe arms fixed to the key-rollers: *d*, *d*, *d*, the key wires, fixed to the arms, *b*, *b*, and to the keys C, D, E. Now when the end of any one of the keys C, D, E, is put down, it pulls down the arm *b*, by the wire *d*, which turns about the roller *s* with the arm *a* that pulls down the wire *w*, which opens the valve, that is ſhut by the ſpring as ſoon as the preſſure is taken off the key. In this conſtruction there muſt be a worm-ſpring faſtened to the key, and to the bar W, on the farther ſide, to keep down the end 5, of the key.

Another method of opening the valves is thus: *x y*, *x y*, are ſlender levers, moveable on the centers 1, 1: 5 *x*, 5 *x*, are wires going from the farther ends of the keys to the ends *x* of the levers: *y* V, *y* V, are other wires, reaching from the ends *y* of the levers, through the holes *h*, to the valves V. So that putting down the key C,D, &c. raiſes the end 5, which truſts up

up the end *x* of the lever, by the wire 5 *x*; this depreſſes the end *y* of the lever, which pulls down the wire *y* V, and opens the valve V.

A third way of opening the valves is this: at the end of the key 6, is a lever 8, 9, moving in the center 7. This makes with the key, a compound lever. From the end 9, a wire goes to the valve. Now the putting down the end 6 of the key, raiſes the end 8, which depreſſes the end 9, of the lever 8, 9, pulls down the wire, and opens the valve. There is only one of theſe drawn in the ſcheme, and but a few of the others; to avoid confuſion.

R, R, are the rollers, to move the ſliders, by help of the arms *cf*, *cf*, which are fixed horizontally in theſe rollers; *k e*, *k e*, are alſo levers fixed in the rollers; *l e*, *l e*, are the handles, which lie horizontally, and paſs through the holes *l l*; they are

faſtened to the lever *k e*, being moveable about a joint at *e*.

Now, any handle *l p*, being drawn out, pulls the end *e* toward *l*, which turns about R *k*, along with the arm *c f*; and the end *f* pulls out the ſlider *f g*; and when *p* is thruſt in, the arm *c f* likewiſe thruſts in the ſlider *f g*.

Upon the ſeveral rows of holes which appear on the top of the upper board, there are ſet up an equal number of rows of pipes. The pipes of an organ are of two kinds, the one has a mouth like a flute, the other with reeds. The firſt, called pipes of mutation, conſiſt (1.) of a foot AA, BB (Fig. 3.) which is a hollow cone, that receives wind that is to ſound the pipe: (2.) to this foot is faſtened the body of the pipe B B D D. Between the foot and the body of the pipe is a diaphragm or partition FEF, that has a long

but

but narrow aperture, by which the wind comes out: over this aperture is the mouth B B C, whoſe upper lip C, being level, cuts the wind as it comes out.

The pipes are of pewter, of lead mixed with a twelfth part of tin, and of wood. Thoſe of pewter are always open at their extremities: the diameter is very ſmall, and their ſound very clear and ſhrill. Thoſe of lead mixed with tin are larger: the ſhorteſt are open, the longeſt quite ſtopped: thoſe of a mean ſize are partly ſtopped, and have beſide a little ear on each ſide the mouth, to be drawn cloſer or ſet farther aſunder, in order to raiſe or lower the ſound. The wooden pipes are ſquare and the extremity is ſtopped with a valve or tampion of leather. The ſound of the wooden and leaden pipes is very ſoft: the large ones ſtopped are commonly of wood, the ſmall ones of lead. The longeſt pipes give the graveſt ſound and the ſhorteſt the moſt acute: their lengths and widths

are determined by a fixed proportion to their ſounds, and their diviſions are regulated by a rule, which is called the diapaſon. The longeſt has commonly ſixteen feet; but in very large organs it has thirty-two feet. The pedal tubes are always open, though made of wood and of lead. Whatever note any open pipe ſounds, when its mouth is ſtopped, it will ſound an octave lower; and a pipe of twice its capacity will likewiſe ſound an octave lower.

A reed pipe conſiſts of a foot A A B B, (Fig. 4.) that carries the wind into the ſhalot or reed C D, which is a hollow demi-cylinder, fitted at its extremity D, into a ſort of mould, by a wooden tampion G. The ſhallot is covered with a plate of copper K K L L, fitted at its extremity I I, into the mould, by the ſame wooden tampion. Its other extremity K K, is at liberty, ſo that the air entering the ſhallot makes it tremble, or ſhake againſt the reed; and the longer that part of the

tongue

tongue IL, which is at liberty, is made, the deeper is the ſound. The mould II, that ſerves to fix the ſhallot or reed, the tongue, tampion, &c. ſerves alſo to ſtop the foot of the pipe, and make the wind go out wholly at the reed. Laſtly, in the mould is ſoldered the tube HH, whoſe inward opening is a continuation of that of the reed: the form of this tube is different in different ranks of pipes. The degree of acuteneſs or gravity in the ſound of a reed-pipe, depends on the length of the tonge, and that of the pipe CK, taken from the extremity of the ſhallot, to the extremity of the tube. The quantity or intenſion of the ſound depends on the width of the reed, the tongue, and the tube; as alſo on the thickneſs of the tongue, the figure of the tube, and the quantity of wind. To diverſify the ſounds of the pipes, a valve is added to the port-vent, which makes the wind go out in fits or ſhakes. In Fig. 1. X repreſents a flute-pipe of wood, Z a flute-pipe of metal, Y a trumpet-

pet-pipe of metal. The pipes, to prevent them from falling, paſs thro' holes made in boards, placed upon the upper board.

The pipes are made to communicate with the wind-cheſt in the following manner. There are holes bored that go thro' the upper and lower boards, and through the ſlider, (when it is drawn out) into the partition below; ſo that any pipes placed upon thoſe holes will then communicate with the partition, which, by its valve, communicates with the wind-cheſt. But when the ſlider is thruſt in its holes do not anſwer to thoſe in the upper and lower boards, therefore the communication is ſtopped, ſo that no wind can get to the pipe.

To every large organ there muſt be at leaſt two pair of bellows, which are marked in Fig. 1. by 9 T, 9 T. O, O, are the handles, moving upon the axes *n n*, *n n*.

Each

Each of thefe bellows confifts of two boards, the loweft of which is immoveable; and in this there is a valve *r*, opening inwards and a tube leading to it, called the conveying tube. There is alfo a hole in this under board, from which a tube leads to the port-vent, which is a fquare tube marked 4, rifing upward, and inferted into the under fide of the wind-cheft at 2. In the tube leading to the port-vent there is a valve that opens toward the port-vent, and fuffers the air to go up the port-vent, but not to return. Now the handle O being put down, raifes the upper board T, and the air enters through the valve *r*, and when the handle is let go, the weight of the upper board, which carries three or four pound to every fquare foot, continually defcending, drives the air through the port-vent to the found-board: and as the bellows work alternately one pair is conftantly defcending, which occafions a continual blaft through the port-vent. In chamber-organs there is but one pair of bellows,

bellows, but they are formed of three boards, in the manner of a ſmith's bellows, and ſo have a continual blaſt. All the internal ſtructure of the organ is concealed from the ſight by the front of the inſtrument, which ſtands upon the part between the numbers 3 and 6 (Fig. 1.)

In every organ the number of partitions LL, MM, &c. there are in the found-board (Fig. 1.) that of the valves V, V; that of the rollers *s*, *s*; or of the levers *x*, *y*, or 8, 9, and their wires: and that of the keys A B C, &c. muſt be always equal. Large organs have commonly four or five ſets of keys, beſide thoſe that belong to the pedals or large pipes, the ſtops to which are played by the feet. The keys of an organ are uſually divided into four octaves, which are, the ſecond ſub-octave, firſt ſub-octave, middle octave, and firſt octave. Each octave is divided into twelve ſtops or frets, of which ſeven are black and five white; the former mark the natural

tural notes, and the latter the artificial notes, that is, flats and ſharps. The number of keys, therefore, when there are four octaves, muſt be 48. Some organiſts add one or more ſtops to the firſt and ſecond ſub-octaves. The pedals have two or three octaves, at the option of the organiſt; ſo that the number of ſtops is indeterminate. The keys are placed between C C (Fig. 1.) but the ſcheme could not contain them all. There are alſo as many handles *l*, *l*, &c. rollers R, R, &c. ſliders *f*, *f*, &c. as there are ſtops upon the organ; and it muſt be obſerved, that between the ſliders *f*, *f*, &c. there are as many ſliders on the right hand, and the ſame number of handles and rollers, and other rows of pipes placed between L N, P Q, &c. which could not be expreſſed in the figure.

The leaſt pipes and partitions are placed toward the middle of the organ, and the greateſt on the outſide. The ſtops of

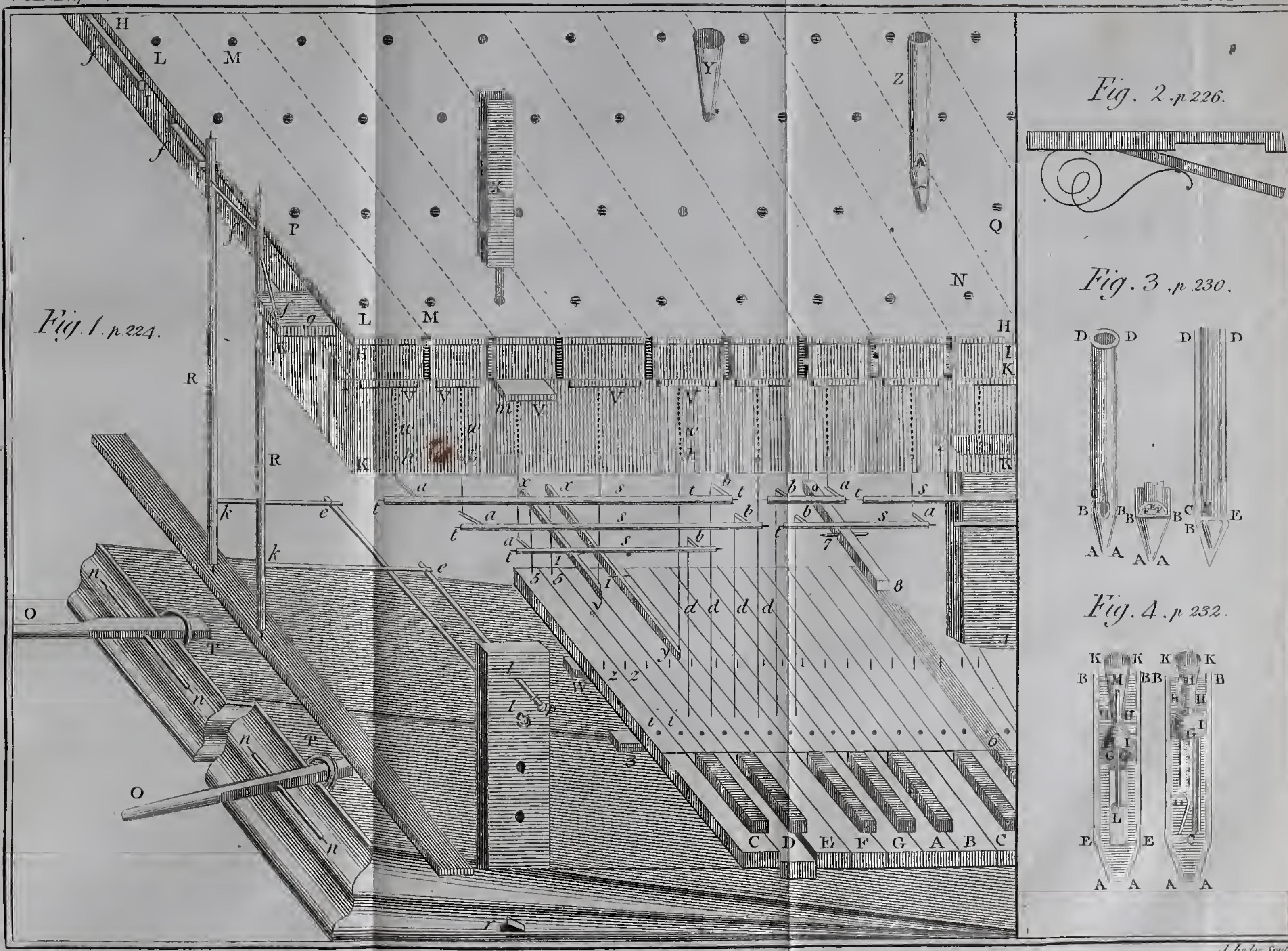
of an organ have various denominations, according to the ſounds they are to produce; ſome of which are diapaſon, principal, fifteen, twelve, tearce, cornet, trumpet, French horn, vox humana, flute, baſſoon, Cremona, &c. There is a contrivance to ſwell the notes of ſome of the ſtops, by placing the treble or ſmall pipes in a kind of cheſt, which is perfectly cloſed or opened with the foot by means of a pedal. When the pipes are cloſe ſhut up, the ſound is ſcarce audible and ſeems to be at a great diſtance; but as the cheſt is wholly or in part opened or cloſed, in a gradual and uniform manner, the ſound of the pipes is increaſed or diminiſhed in the ſame proportion. In large organs, the upper or half-row of keys belong to theſe pipes; and when this part is managed by a good performer, it yields the moſt delightful muſic imaginable.

When this magnificent inſtrument is played, the handle O of the bellows is firſt put down, which raiſes the upper board T,

T, and gives room for the air to enter by the valve *r*. Then the other handle O is put down; in the mean time the board T, belonging to the firft handle, defcending, and fhutting the valve *r*, drives the air, through the other valve, up the port-vent, and into the wind-cheft. Then drawing out any handle, as that of the flute-ftop, *pl*, which draws out the flider *fg*, all the pipes in the fet LN are ready to play, as foon as the keys C,D,E, &c. are put down; therefore, if the key D be put down, it opens the correfponding valve *m* V, thro' which the air enters into the pipe X, and makes it found. In the fame manner any other pipe, in the fet LN, will found when its key is put down; but no pipe, in any other fet, will found, till the flider be drawn out by its correfponding handle.

The organ is not only the moft grand but the moft ancient of all compound mufical machines. Vitruvius defcribes an hydraulic organ in the tenth book of his architecture

chitecture, which was celebrated by the emperor Julian, in an epigram. St. Jerome mentions an organ that had twelve pair of bellows, and whose found might be heard at the diftance of a mile.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C D E F G A B C
J. Lodge Sculp.

THE

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RECREATION I. p. 14

Optical illusion.

Three pieces of money being placed in vessel (Pl. III. Fig. 1.) out of the view of a spectator, and water being poured into the vessel all those pieces become visible—by the refraction of the light through the water.

RECREATION II. p. 15

Optical augmentation.

A shilling being put in a glass of water, and a plate placed upon it, the glass is turned over with the plate, and there appears a half crown on the plate and a shilling over it—by the seeing the shilling through the top and the side of the water at the same time, and the different refraction of the light.

RECREATION III. p. 17

Optical fubtraction.

Three fmall pieces of paper being placed againft a wall, (Plate III. Fig. 2.) a perfon by fhutting one of his eyes can fee only two of them—the rays that come from one of the pieces falling always on the optie nerve, and not on the retina.

RECREATION IV. p. 18

Alternate illufion.

A filver feal when viewed through a eon-vex lens, appears alternately engraved and in relief—eonjecture on the caufe of this remarkable phenomenon p. 90 (note)

RECREATION V. p. 20

The camera obfcura.

A convex lens is placed in the window-fhutter of a dark room, and a coneave

paſteboard lined with white paper, is placed in the focus of the lens, whereby the objects without the room are painted on the paper, but inverted—method of making them appear erect, page 22 (note)—this apparatus improved by a mirror placed in different poſitions, p. 22—preſents the moſt pleaſing and natural of all pictures 25

RECREATION VI. p. 25

To ſhew the ſpots on the ſun's diſk, by its image in the camera obſcura.

By placing a ſcioptric ball, that is, a ball of wood in which a lens is fixed, oppoſite the ſun, which will throw its image on the paper—this image to be viewed through another lens, p. 26

RE-

RECREATION VII. p. 27

To magnify ſmall objects by means of the ſun's rays let into a dark chamber.

By throwing the rays on a concave mirror and holding the ſmall objects, ſtuck on ſlips of glaſs, near the focus of the mirror, by which means their images are reflected on the wall.

RECREATION VIII. p. 28

The portable camera obſcura.

A plate of glaſs is placed in a horizontal frame of wood that is ſupported by four legs, which fold up (Plate III. Fig. 3.) Under the frame is a box, that likewiſe folds up, and at the bottom of it are a tube and a mirror, by which the objects are reflected to the glaſs—advantage of this camera over others, p. 30—manner of drawing objects by this machine p. 31

RECREATION IX. p. 32

The magic lantern.

The origin of this machine—it confifts of a tin box, at one end of which is a concave mirror ; in the other end is fixed a lens, and between them is placed a lamp : before the lens is fixed a fquare tin tube in which there is a groove, and through this groove the glaffes that contain the objects are paffed : in this tube is placed another, that is moveable, and contains two lenfes, which throw the objects on a cloth—method of painting the glaffes, p. 37—propofal of improving this machine by ufing moveable objects. p. 39

RECREATION X. p. 40

To reprefent a tempeft by the magic lantern.

By paffing two glaffes, on one of which is painted the fea and fky, and on the other

other ſhips, (Plate IV. Fig. 1 and 2) through the groove at the ſame time, and giving them a proper motion—by the ſame method a battle, and many other ſubjects may be exhibited p. 42

RECREATION XI. p. 43

The nebulous magic lantern.

At the bottom of a ſquare box, whoſe height is equal to ſix times its width, (Plate IV. Fig. 3.) is placed a chaſing-diſh of hot coals, on which incenſe is burnt, and on the ſmoke that comes out of the top of the box is thrown the figures of the magic lantern.

RECREATION XII. p. 44

To produce the appearance of a phantom, on a box or pedeſtal placed on a table.

A common magic lantern is placed in a box, (Plate IV. Fig. 4.) in which there is an inclined mirror, that reflects the

light of the lantern on the thick ſmoke of a chafingdiſh of coals placed on the box, and ſhows the image reflected by the glaſs—this Recreation muſt be performed in a dark room, p. 47

RECREATION XIII. p. 48

The magical theatre.

A magic lantern muſt be provided that has a tube in two of its oppoſite ſides, (Pl. IV. Fig. 5.) in one of which tubes there muſt be ſeveral grooves, by which the ſubjects to be repreſented may be paſſed either horizontally, aſcending, or deſcending, and two or more of them at the ſame time. In the partition between the room where the lantern is, and that where the exhibition is to be ſeen, there muſt be placed a glaſs, covered with thin paper, on which the objects are to be thrown—example of a repreſentation of the ſiege of Troy, in five acts, p. 52—it is quite neceſſary that the glaſſes

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RECREATION XIV. p. 67

The boundleſs gallery.

Againſt each of the two ſmalleſt ends of an oblong box (Plate VI. Fig. 1.) is placed a plain mirror, and from one of them the quickſilver is taken off for the ſpace of an inch and a half, oppoſite which a hole is made in the box: the top of the box is covered with glaſs, and between the mirrors are placed ſcenes properly painted, which, when viewed from the hole at the end of the box

box appear as an endlefs vifta or gallery.

RECREATION XV. p. 69

The four magical mirrors.

The infide of a fquare box (Pl. VI. Fig. 4) is lined with four mirrors: the top is covered with five planes of glafs in form of the lower part of a pyramid, and on the bottom of the box are placed certain objects in relief, which, when feen from the top are fo reflected by the mirrors as to form an unlimited fpace completely covered with objects.

RECREATION XVI. p. 72

The enchanted palace.

From the center of a hexagon to its circumference are drawn fix lines, at equal diftances, (Plate VII. Fig. 1.) and on each of them are fixed two mirrors, which are fupported by pillars placed at

at the circumference: the top is covered with a dome, and between the six-spaces objects are placed, which are reflected six times, and produce a very pleasing appearance.

RECREATION XVII. p. 75

To draw an irregular figure, which shall appear regular when viewed in a plane mirror.

The figure is to be first drawn on a square that contains a number of equal divisions, (Plate VII. Fig. 2.) and then the several parts transferred to the same number of divisions in a trapezium; and that distorted figure, when seen in the mirror from a determinate point of view, will appear in its natural form.

RECREATION XVIII. p. 78

The magical dial.

A dial-plate, that has a magnetic needle for a hand, is placed at the bottom of

of a dial caſe and towards the top of the caſe is fixed a mirror, by which the figures of the hours are reflected to the part where the dial is commonly ſeen. Another dial plate, at the back of which is concealed an artificial magnet, that is moved by the hand of that dial, is given to a perſon, who ſetting the hand privately to any hour, puts it in a drawer at the bottom of the dial-caſe, under the firſt mentioned dial, and looking in at top he ſees the reflection of the dial there, anſwer to the hour at which he ſet the other dial; the hand of the firſt being moved, by the the attraction of the magnet in the other, to the ſame hour.

RECREATION XIX. p. 81.

The box of divination.

A box that contains four caſes, on each of which a number is wrote, and at the bottom of which a magnet is concealed, (Plate

(Plate VIII. Fig. 1.) is placed on a table: under that part of the table are placed four moveable circles, that have each a needle, and under them is a drawer, that contains a mirror, ſo that by looking into the drawer you ſee, by that mirror, in what order are placed the boxes that have the numbers.

RECREATION XX. p. 84

The magical perſpectives.

A ſmall common perſpective (Plate VIII. Fig 6.) is fixed on a hollow ſtand of wood; in this perſpective is placed a mirror, which is moved by the inner tube, ſo as to ſhow any object under the hollow ſtand. Three of theſe perſpectives are ſet over three holes in the top of a box, (Fig. 5) at the bottom of which is placed a moveable circle, that is divided into twenty-one equal parts, and contains a magnetic needle: this box is ſet on a table, under which

is

is concealed a magnetic bar, that being privately placed in any poſition, determines that of the circle in the box, and conſequently brings any of the objects painted on it under the ſeveral perſpectives.

RECREATION XXI. p. 93

The penetrative perſpective.

In a box or caſe that has two prominent parts or arms, (Plate X. Fig. 1.) are placed four mirrors, and in each of the arms is fixed the tube of a perſpective glaſs, ſo that the object next the end of one perſpective, being reflected by the four mirrors, is ſeen at the end of the other, and appears as if viewed through the two perſpectives, and conſequently is perfectly viſible when an opaque body is placed between thoſe two perſpectives.

RE-

RECREATION XXII. p. 96

The magician's mirrors.

Two glaſſes are fixed in the partition of a room, at about a foot diſtant from each other; behind theſe glaſſes are placed two mirrors, inclined in a proper angle, ſo that a perſon looking into one of them, inſtead of ſeeing his own face ſees that of another perſon who at the ſame time looks into the other glaſs. Method of improving this Recreation, by putting two glaſſes in adjoining rooms, p. 97—properties of plain mirrors when placed in different poſitions, p. 98.

RECREATION XXIII. p. 100

Polemoſcopes.

Theſe inſtruments conſiſt of a tube that contains an inclined mirror, and has an

eye

eye-glafs of a proper focus, fo that while the tube is pointed at one object you fee another. By placing an inftrument of this fort at the top of a wall, while you ftand at the bottom, you fee what paffes on the other fide, p. 101

RECREATION XXVI. p. 102

The enchanted mirrors.

In four parallel fides of a cubical box are fixed four glaffes, reprefenting mirrors, and within the box are placed two mirrors, that crofs it diagonally. When four perfons look into the glaffes, each of them fees, inftead of his own face, that of the perfon next him, and who appears at the fame time to be placed directly oppofite to him.

RECREATION XXV. p. 103

The animated optic balls.

This pleafing piece of optics confifts of an oblong box, (Pl. IX. Fig. 2.) three fourths of the upper part of which is divided from the lower by a horizontal partition, and is decorated with paintings. In the lower part of the remaining fourth is placed an inclined plane, in the middle of which is a ferpentine groove, and in the other parts are paintings or objects in relief: in the upper part of this fpace is a mirror, placed in a proper angle to reflect the objects on the plane. At the end of the box is a fmall opening, by which ivory balls, that may be painted with different colours, are put in, and running down the groove in the inclined plane, pafs out at the bottom, and are raifed to the fame opening again by a machine placed

there ſor that purpoſe. Part of the top of this box is covered with glaſs, lined with gauze, and near the inclined plane is placed a lamp. In the end of the box oppoſite the plane, there is an opening in which a glaſs is fixed, and thro' which the objects on the inclined plane are ſeen, reflected by the mirror, and being all inverted, the balls ſeem to roll up the mirror, and paſs out at the top of the box.

RECREATION XXVI. p. 111

The optic balls by a double reflection.

This box differs from the laſt in having a mirror where the inclined plane is there placed, and in the planes being placed at the oppoſite end of the box. There may alſo be an additional number of grooves, with a ſmall inclination, thro' which the balls may paſs: and if there be ſufficient room, there may be two ſets of grooves, by which the balls will ſeem in the mirror to rencounter and paſs over each other.

RECRE-

RECREATION XXVII. p. 114

To deſcribe on a plane ſurface an irregular figure, which ſhall appear regular when placed oppoſite a multiplying glaſs, and ſeen by reflection through an aperture made in the center of the drawing.

The plan of the multiplying glaſs (Plate X. Fig. 4.) being drawn on paper, the deſign is to be drawn on that. The glaſs is to be fixed on a ſtand at one end of a box, and at the other end is to be a frame that holds a paper, in the middle of which is a hole, and on which is to be transferred the deſign drawn on the multiplying glaſs, and which will then be quite diſtorted; but being ſeen in the mirror, by looking through the hole, it will appear quite regular.

RECREATION XXVIII. p. 120

To describe on a plane surface a deformed figure, which shall appear regular when viewed by reflection in a cylindrical mirror.

Part of the surface of the cylinder (Pl. XI. Fig. 1.) is to be divided by lines, into twelve parts, in proportion to those of the diameter of the circle CD, Fig. 2. The paralelogram, Fig. 3. is likewise to be divided into twelve equal parts, and on them a regular figure is to be drawn, and then transferred to the same number of parts, which will be reflected on the plane DG, by the lines on the cylinder, and the figure will then appear deformed, but being seen from the point of view E, will be quite regular. A similar experiment may be made with prismatic and other mirrors, p. 124

RECREATION XXIX. p. 123

Optical appearances.

A bottle half full of water being placed near the focus of a concave mirror, appears not only inverted, but the water at the top of the bottle, and the bottom of the bottle empty. If the bottle be inverted and placed before the mirror its image will appear erect, and the water at the bottom of the bottle. If while the bottle is inverted it be uncorked, it will appear, that while the upper part is emptying the bottom part is filling.

RECREATION XXX. p. 128

The perſpective mirror.

At one end of an oblong box (Plate XII. Fig. 1.) is placed a concave mirror; near the upper part of the oppoſite end a hole is made, and about the middle of the box is placed a hollow frame of

paſteboard, that confines the view of the mirror. The top of the box next that end in which the hole is made is covered with a glaſs; and under the hole are placed, in ſucceſſion, different pictures, properly painted, which are thrown into perſpective by the mirror, and produce an appearance that is highly pleaſing.

RECREATION XXXI. p. 130

To ſet fire to a combuſtible body, by the reflection of two concave mirrors.

Theſe two mirrors (Plate XII. Fig. 2.) are placed at a conſiderable diſtance, and in the focus of one of them is put a live coal, in that of the other ſome gunpowder and by the blowing on the coal, the gunpowder will take fire, though the diſtance between the mirrors be ſeveral feet.

RECREATION XXXII. p. 132

The real apparition.

A hole is made in a partition, (Plate XII. Fig. 3.) and behind it is placed a large concave mirror, and a ſtrong light, that muſt not be viſible at the hole. On the ſame ſide of the partition, and directly under the hole, is fixed, in an inverted poſition the object that is to appear without the partition. A perſon being placed in a proper point of view will ſee the object on the outſide, and in an erect poſition.—The figure of an abſent or deceaſed friend may be made to appear by this method, p. 134—The imaginary combat by a concave mirror, p. 136

CHROMATICS.

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RECREATION XXXIII. p. 140

Out of a ſingle colourleſs ray of light to produce ſeven other rays, which ſhall paint, on a white body, the ſeven primary colours of nature.

A round hole is made in the window-ſhutter of a dark room, and the ray of light that enters at the hole, falling on a priſm, is refracted, and being thrown on a paper placed at a proper diſtance, forms an oblong ſpectrum that exhibits all the primary colours of nature.

RECREATION XXXIV. p. 142

From two or more of the primary colours to compoſe others that ſhall, in appearance, reſemble thoſe of the priſm.

By mixing any two of the primary colours, as yellow and blue, the intermediate colour, green, will be formed; but theſe mixed colours, though ſimilar in appearance to the primary, yet when

viewed

viewed through a priſm, are reſolved into the colours of which they are compoſed.

RECREATION XXXV. p. 144

Out of the three primary colours, red, yellow and blue, to produce all the other priſmatic colours, and all that are intermediate to them.

Three panes of glaſs are divided, each of them into five equal parts, and over thoſe parts are paſted a different number of papers painted either red, yellow, or blue, (Pl. XIII. Fig. 2.) When one of theſe glaſſes is put in a box, open at two oppoſite ends, all the gradations of the colour it contains are viſible; and when two of them are placed together, Fig. 3, the intermediate colour appears with its ſeveral degrees.

RECREATION XXXVI. p. 147

By means of the three primary colours, red, yellow, and blue, together with light and ſhade,

ſhade, to produce all the gradations of the priſmatic colours.

On ſeven ſquare panes of glaſs papers are paſted that contain all the priſmatic colours, and over them are put a different number of pieces, tinged with a deep ſhade, and they are then placed in a box, in the ſame manner as in the laſt Recreation. Method of printing in colours, p. 148.

RECREATION XXXVII. p. 150

The magical priſm.

A ray of light that comes through a hole made in the window-ſhutter of a dark-chamber, falling on a glaſs priſm, (Plate XIII. Fig. 4.) is refracted on a hollow priſm of wood, that revolves on an axis, and in whoſe ſides figures are cut. As this priſm changes its poſition with regard to that of the glaſs, the figures cut out will appear white, yellow, and red, or blue and violet.

RECRE-

RECREATION XXXVIII. p. 152

The ſolar magic lantern.

A ſmall box that is open at two oppoſite ſides, is placed againſt a hole of the ſame ſize in the window-ſhutter of a dark chamber, that faces the ſun. Through this box are paſſed, by a groove, paſteboard blacked, and through which different figures are cut These figures, when viewed through a priſm, appear to be painted with the moſt lively colours in nature. This Recreation may be diverſified by paſting papers tinged with different colours, over the figures in the paſteboard.

RECREATION XXXIX. p. 154

The artificial rainbow.

Oppoſite a window on which the ſun ſhines, a glaſs globe filled with water is ſuſpended by a ſtring that paſſes over a pulley; and when it is drawn up to a certain height, which may be found by trial,

trial, the colours of the rainbow will appear in it: when it is drawn up a little higher the colours disappear, and when it is drawn up still higher they appear again, and at last totally disappear. The phenomena of the natural rainbow explained by this experiment, p. 155

RECREATION XL. p. 158

The prismatic camera obscura.

Two holes are made in the shutter of a dark chamber (Plate XIII. Fig. 5.) and against each of them a prism is placed, in such manner that both their spectrums are cast upon the same spot. Several papers, of the same dimension with the spectrums, have lines drawn on them parallel to the divisions of the colours, and between those divisions figures are cut out, which then appear to be painted with all the primary colours. This Recreation may be diversified by turning one of the prisms round; and by looking at the spectrums through another prism, p. 159.

RE-

RECREATION XLI. p. 160

The diatonic ſcale of colours.

The ſun's ſpectrum is to be largely refracted on a paper, and the diviſions of the ſeveral colours ſet off, when they will be found to correſpond to the diviſions of a muſical chord for the notes of an octave.

RECREATION XLII. p. 162

Colorific muſic.

The ſurface of a hollow cylinder (Plate XIV. Fig. 2.) is divided vertically into ſix equal parts, and horizontally into forty-one parts; in each of the latter parts ſpaces are cut, over which are paſted papers that are painted with the ſeven primary colours. At the bottom of this cylinder is a wheel, an endleſs ſcrew, and a nut; and when it is placed in a caſe, Fig. 3, the endleſs ſcrew is turned

turned by a handle, which turns the wheel, and raiſes the cylinder by means of the nut at bottom, the height of five of its horizontal diviſions, and conſequently ſhows the ſeveral colours it contains at the eight apertures made in the front of the caſe. A lamp is ſuſpended from the top of the caſe, which hanging within the cylinder, ſhows the colours that anſwer to the notes of muſic, and the length of thoſe colours correſponds to the duration of the notes.

PERSPECTIVE RECREATIONS.

RECREATION XLIII. p. 168

To draw on a plane ſurface an irregular figure, which, when ſeen from a proper point of view, will appear ſimilar to a given figure.

A paralelogram is divided into forty-eight equal parts, (Plate XV. Fig. 1.) on which the regular figure is drawn, and

its

its ſeveral parts tranſpoſed, to an equal number of diviſions in a trapezium, where the figure will appear deformed, but when ſeen from a proper point of view, quite regular. The correſponding parts in the parallelogram and trapezium are to be numbered, p. 172— Theſe figures appear to great advantage when painted on the ſide of a gallery, p. 174.

RECREATION XLIV. p. 175

To draw an irregular figure on a plane, which being ſeen from two oppoſite points of view, ſhall repreſent two different regulations.

The two regular ſquares are to be firſt drawn on the two parallelograms. (Pl. XVI. Fig. 3.) and then transferred to the diviſions of the paralellogram, Fig 2. On a board Fig. 4, of the ſame ſize with the laſt figure, lines are cut, in which

which a paper, Fig. 5, is pasted, and the distorted figure on it: which when seen from two proper points of view, will present two regular figures.

RECREATION XLV. p. 181

To draw on the base of a cone, an irregular figure, which shall appear, when seen from a proper point of view, not only regular, but elevated above the surface of the cone.

The cone is placed in a board, (Pl. XVII. Fig. 1.) with its base upward, and at one end of it is fixed a perpendicular plate of glass, on which the regular figure is drawn. At the point of view a lamp is placed, by which the figure on the glass is thrown on the base of the cone, and there traced. The lamp and glass are then taken away, and the distorted figure, when seen from the point of view appears not only regular, but erect

erect, and in the same situation it was on the glass.

RECREATION XLVI. p. 186

To draw, easily and correctly, a landscape, or any other object, without being obliged to observe the rules of perspective, and without the aid of the camera obscura.

In the largest end of a box (Plate XVII. Fig. 3.) there is a frame, divided into a number of equal divisions, and in the opposite end is a tube. This box is supported on a stand. You are provided with a paper that has the same number of divisions as the frame in the box, and looking through the tube you transfer the several objects seen through the divisions of the frame to those on the paper.

RECREATION XLVII. p. 189.

Illuminated prospects.

The top of a print, properly painted, is cut off, and put in a frame, and the lower part in another frame. These two frames

are placed in a box, (Pl. XVII. Fig. 5.) at different diſtances, and behind them lights are ſet, and when they are viewed from the front of the box, and there is no other light in the room, they afford a very pleaſing appearance.

RECREATION XLVIII. p. 191
Tranſparent illuminations.

Thoſe parts of a print where the light is to appear are cut through with a fine tool. The print is then put in a frame and placed in the box deſcribed in the laſt recreation: behind it is a yellow tranſparent paper, and behind that are lights. Theſe ſcenes are to be moveable, ſo as to repreſent a ſucceſſion of objects differently illuminated.

ACOUSTICS.

DEFINITIONS p. 195
APHORISMS 196

Nature of ſonorous bodies, aph. 1 to 5.—Vibrations of chords, aph. 6 to 9.--Propagation of ſound, aph. 10 to 14.—Strength and reflection of ſound, aph. 15 and 16.

RE-

RECREATION XLIX. p. 201

The eolipiles.

A ſmall metal globe, with a ſlender neck, is thrown when hot, into a veſſel of water, and when it is put on a fire the water ruſhes out with a great noiſe—this phenomenon improved by fixing the calls uſed by fowlers to the necks of theſe eolipiles.

RECREATION L. p. 202

The communicative buſts.

Two buſts are placed on pedeſtals on the oppoſite ſides of a room, and from the mouth of the one there goes a tube under the floor, to the ear of the other. Therefore, if a perſon ſpeak into the ear of one buſt, another perſon, who applies his ear to the mouth of the other buſt, will hear diſtinctly all the firſt utters; and at the ſame time other people, in the middle of the room, will hear nothing of what paſſes.

RECREATION LI. p. 203

The oracular head.

This recreation is performed by a fingle head, and tubes, that go from the ear and mouth of it, to a room underneath, where a confederate hears what is faid, and returns an anfwer; and there are wires by which the eyes and lips of the buft are moved at the fame time.

RECREATION LII. p. 204

The folar fonata.

A barrel organ is placed in a cafe, that has a glafs front, behind which is a tube with fpirits, and on that a cork floats, which, when it rifes to a certain point, by the heat of the fun, lifts up a catch, and fets the organ in play; but when the machine is carried into the cold the fpirits fink, and the catch again ftops the organ.

RECREATION LIII. p. 207

An automatous harpfichord.

There are wires that go from the under part of the keys of a harpfichord, and a

barrel with pins, that take the ends of thoſe wires. Round the axis of the barrel goes a ſtring, that paſſes under the floor, and communicates with a ſmoke-jack, by which the harpſichord is played inceſſantly.

RECREATION LIV. p. 209

A ventoſal ſymphony.

On the top of a houſe there is a vane, (Pl. XVIII. Fig. 3.) at the bottom of which, and within the roof of the houſe, is a wheel that communicates, by other ſmall wheels and pinions, with a large barrel in the room underneath: to this barrel a number of ſtops are fixed, and cloſe to it are hung twelve bells; therefore as the vane is turned by the wind, the ſeveral ſmall wheels being put in motion, turn the barrel, and by making it ſtrike the bells, according to the poſition of the ſtops, play the ſymphony.

RECRE-

RECREATION LV. p. 211

The nocturnal reveilleur.

On the circumference of a wheel are placed a number of bells, and round its axis is wound a rope, at the end of which is faſtened a weight that reſts upon one end of a moveable lever, and is balanced by a hollow cone, filled with ſand, hung to the other end of the lever, but as the ſand runs out the weight deſcends and by turning the wheel rings the bells.

RECREATION LVI. p. 214

A muſical caſcade.

A large wheel is placed under a caſcade, the water of which is confined to the ends of the wheel; the middle of this wheel conſiſts of bars, in which ſtops are placed, that by ſtriking a certain number of bells play one or more tunes, at pleaſure.

RECREATION LVII. p. 216

Reverberated ſounds.

Conſtruction of a whiſpering gallery—the nature of echoes, p. 217—of reverberated echoes, p. 219.

RECREATION LVIII. p. 220

The converſive ſtatue.

There are two large concave mirrors, and in the focus of one of them is placed the figure of a man (Pl. XVIII. Fig. 5.) The other mirror is placed behind a partition, in which is an opening, concealed by a gauze. When a perſon ſpeaks ſoftly in the ear of the ſtatue, which is exactly in the focus of one of the mirrors, another perſon placing his ear in the focus of the other mirror will hear diſtinctly what is ſaid, and anſwering ſoftly at the ſame point will be heard by the firſt perſon.

RECREATION LIX. p. 223

The great organ.

The body of this noble inſtrument conſiſts of a wind-cheſt, (Pl. XIX. Fig. 1.) over which is placed two boards, that form what is called the ſound-board. in the under ſide of the lower board are ſeveral partitions, and in its upper ſide

are

are cut channels, in which sliders are placed, in a transverse position to the partitions. There are holes made thro' the upper board, sliders and under board, into the partitions; and in the holes of the upper board the pipes are placed that produce the sounds. There are two pair of bellows, by which the air is forced into the chest. When any one of the sliders is drawn out, its holes correspond with those in the upper board and in the partitions. At the front end of each partition is a valve, under which is a hole into the wind-chest; these valves are connected with the keys of the organ by wires, so that when a key is put down it opens a valve and the air rushes into the partition, and the slider being drawn out it passes through the holes in that and the upper board into the pipe placed over it, and makes it sound.

THE END OF THE SECOND VOLUME.